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HISTORICAL MILESTONES IN THE PROGRESS OF ARTIFICIAL RADIOACTIVITY

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Although natural transmutation was well known and observed as early as 1896, as late as twenty years ago the processes of artificial disintegration were as "remote from human handling" as the condition of the weather. True it is that the alchemists of old unremittingly searched for the philosopher's stone which was to transmute base metal into gold. They even made reports concerning the discovery of it from time to time. The processes were kept a deep, dark secret and not a milligram of gold was proffered to prove it. We have good reasons to be skeptical about the truth of these findings. As chemistry advanced the idea of transmutation became more and more obsolete. A periodic table was constructed which consisted of 92 immutable elements and the mystical old alchemists were scoffed at.[3]

In 1896, Becquerel, while studying the properties of the heavy salts, found that they were literally quaking and spitting forth particles which caused their death and the birth of new isotopes of elements close to the atomic number of the mother element. This was transmutation, but not man-made. All the king's horses and all the king's men can not prevent the escape, or hasten the departure of an alpha particle from radium.[9]

1919. Rutherford, while making observations on atomic collisions between radium and atoms of gases such as hydrogen, helium, nitrogen, oxygen, discovered when bombarding one of them, namely nitrogen, that a particle of exceptionally long

range was ejected. He made investigations and found that it had a charge and a weight equivalent to monatomic hydrogen. He cautiously mothered his findings until he could be assured of verification, and then kindled the fire for a new blaze of enthusiasm in research. The equation for the reaction follows:

$$_2He^4 + _7N^{14} \rightarrow _1H^1 + _8O^{17}.$$

According to Hull, Rutherford's experiment was the first in history in which we had evidence of one element being transmuted into another.[2]

1932. After a lapse of about ten years of hard work experimenters began to reap meaningful results. Becker and Bothe while bombarding berillium with alpha particles found that a very penetrating radiation was given off. They supposed that this was gamma radiation because it had no charge and because of its deep penetration. Curie-Joliot showed that when this radiation passed through paraffin the ionization instead of being decreased by absorption was greatly increased. Chadwick became interested, stepped in, and with a little research discovered the neutron.[2] This is a very potent particle with no charge and with the weight of a proton. The following equation shows clearly the reaction:

$$_2He^4 + _4Be^9 \rightarrow _6C^{12} + _0n^1.$$

During this same year Anderson, student of Millikan, accidently discovered a particle, equal in charge and weight but opposite to an electron. The particle was called a positron. This discovery was made while the young man was making photographic plates of cosmic showers. The particle has played an important part in artificial radioactivity.[9]

1933. The Joliots discovered that the product of an atom of an artificial disintegration need not always correspond to a stable isotope but could also disintegrate with a relatively long mean life and with the emission of a light particle. The emitted particles as a rule were positrons accompanied by gamma radiation. As bombarding particles the Joliots used alpha particles from poloniun. Similar results were obtained by other experimenters using alpha particles and artificially accelerated protons and deuterons. Because of the law of electrical charges and the small energy of the bombarding particles it was hard to transmute atoms farther down the periodic chart than 15 by this method.[5]

1934. It occurred to Enrico Fermi of the Royal University of

Rome that it might be convenient to try neutrons, as bombarding particles, which because of their zero charge would penetrate the heaviest nuclei. When the first report of this work appeared, in the spring of 1934, 40 out of 60 elements had been found to respond radioactively. It was at this time that Fermi, Amaldi and their associates supposedly discovered element No. 93 and other transuranic elements. This last, however, was disproved as will be explained in a later paragraph.[5]

1934–39. Lawrence and Livingston with their cyclotron outdid the world with their high-energy protons and deuterons. These experimenters did such outstanding work with their "machine gun" that soon a larger and more efficient cyclotron was built. It was for this that Lawrence received the Nobel Prize in 1939. Special mention should be made of the success which Lawrence had in bombarding sodium with deuterons. Sodium becomes strongly radiaoactive and "since sodium is a constituent of food and of body material, there is reason for believing that radioactive sodium may have an important place in hospitals as well as in physics laboratories."[2]

$$_{13}Al^{27} + {}_{0}n^{1} \rightarrow {}_{11}Na^{24} + {}_{2}He^{4}$$

$$_{11}Na^{24} \rightarrow {}_{12}Mg^{24} + {}_{-1}e^{0}$$

1939–40. Fermi's discoveries of element 93 and other transuranic elements were misinterpreted phenomena. In 1939 Hahn and Straussman made an important discovery. After bombarding uranium with neutrons, as did Fermi and his colleagues, Hahn and his collaborators carefully performed a series of chemical separations of the uranium sample to determine the element to which the newly produced radioactivity belonged. They were amazed to find that the radioactive elements were chemically identical with a number of elements nearly all of which are near the center of the periodic table. In other words, a uranium nucleus after the capture of a single neutron seemed to be splitting apart into two nearly equal fragments.

$$_{92}U^{235} + {}_{0}n^{1} \rightarrow {}_{92}U^{236} \rightarrow {}_{50}Sn^{127} + {}_{42}Mo^{104} + 5\,{}_{0}n^{1}$$

After the capture of a neutron the uranium nucleus becomes unstable and fission occurs.[6–4]

1940. The pace at which these new discoveries have occurred has been amazing. Cyclotrons are cropping up all over the country and there is a veritable "blitzkrieg" on the elements running the gamut of the periodic table. As an outcome of this a

multiplicity of modes of disintegration have been introduced. Many of these have been used with favorable results. All told there are some 550 odd disintegrations which may be classified under approximately 20 types.

BIBLIOGRAPHY

1. LEMON, H., *From Galileo to Cosmic Rays*, Chicago, 1935.
2. HULL, G. F., *An Elementary Survey of Modern Physics*, New York, 1936.
3. RUTHERFORD, E., *The Newer Alchemy*, London, 1937.
4. WHITE, H., *Classical and Modern Physics*, New York, 1940.
5. FERMI, E., et al., "Artificial Radioactivity Produced by Neutron Bombardment," *Proceedings of Royal Society*, 146, pp. 483–499, 1934.
6. TURNER, L. A., "Nuclear Fission," *The Reviews of Modern Physics*, 12, pp. 1–29, 1940.
7. AMALDI, E., et al., "Artificial Radioactivity Produced by Neutron Bombardment," *Proceedings of Royal Society*, 149, p. 522, 1935.
8. GROSS, A. V. and AGRUSS, M. S., "Chemistry of Element 93 and Fermi's Discovery," *Physical Review*, 46, p. 241, 1934.
9. YATES, R. F., *These Amazing Electrons*, New York, 1937.
10. LIVINGOOD, J. J. and SEABORG, G. T., "A Table of Induced Radioactivities," *The Reviews of Modern Physics*, 12, pp. 30–46, 1940.

RADIO SERIES TO DEPICT NEGRO CONTRIBUTIONS TO AMERICAN LIFE

A series of educational radio programs planned by the U. S. Office of Education and financed by a Rosenwald Foundation grant will dramatize Negro contributions to American life.

The programs, to be broadcast nationally, will portray the role Negroes have played in American education, art, science, industry, and other fields of endeavor.

The radio series is being prepared under the general direction of Ambrose Caliver, U. S. Office of Education Specialist in the Education of Negroes and William D. Boutwell, Chief, Division of Radio, Publications, and Exhibits.

Plans for the project call for transcriptions of the programs for use in schools, colleges and by local radio stations. The transcriptions, and radio scripts revised as lesson units and study guides, are expected to be used by both white and Negro schools in courses or units of instruction about Negroes in the United States.

The U. S. Office of Education will have the assistance of a technical advisory committee in developing the series of radio programs, and is seeking advice and suggestions from Negroes throughout the United States to be considered in making further plans.

To be included in the series will be the Negro's participation in: Music, literature, art, religion, exploration, invention, scientific research, agriculture, industry, labor, education, civil and military service, theatrical and sports activities.

INTRAVENOUS MEDICATION AS A TREATMENT FOR DISEASE*

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From 1913 to 1916 my services consisted of doing the laboratory work for a large state hospital for the insane. Giving salvarsan to the syphilitic patients was one of my duties. At that time salvarsan was the only drug given intravenously. Blood transfusions were given occasionally but the technique was imperfect and dangerous and where transfusions are given in infectious diseases I think far better results can be obtained by intravenous use of any one of several anti-toxic remedies. In fact, I believe that blood transfusions in cases where the disease germs are in blood stream like in malaria, uremia, or the septicaemias, do more harm than good by feeding the germs rather than killing them, whereas, calcium compounds, iodides, and several others kill, neutralize, and help nature to eliminate them and their toxins.

Some patients I had prior to this period belonged to a certain religious sect who insisted that my dietary practice was wrong. I insisted as strongly that the Bible does not prohibit the eating of meat so I looked it up again and found that God told Noah that he might eat of the flesh of his herds but said, "Thou shalt not eat the blood thereof for it is the life of the body." I do not object to anybody believing what this sect believes. It will not hurt them—There's a sanitarium at Battle Creek, Mich. which has grown to be one of the biggest and best on this same belief. Nevertheless, I still insist that people should eat sparingly of the foods which agree with them and abstain from whatever foods disagree with them. It is not what we eat that defiles us as it is the *amount and manner of eating it.*

However, from that statement . . . "The blood is the life of the body," came my dream of intravenous treatments for any diseased conditions and on account of it I took up my study of intravenous medication to ascertain what remedies might be put directly into the blood stream to kill, neutralize or eliminate whatever poisons we might encounter in our care of suffering humanity. That study has been pleasant, enlightening and profitable both to the doctor and his patients.

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* Read before the General Science Section of the Central Association of Science and Mathematics Teachers, Cleveland, Nov. 22, 1940.

At first I could find only two preparations other than salvarsan which might be used intravenously—one of iron and one of sodium—so I have made my own solutions since then except in rare instances. Now they can be had from several pharmaceutal manufacturers without delay. These firms list many remedies manufactured expressly for intravenous use and give instructions concerning indications and contraindications for their use, also explanations concerning proper technique and the dangers of poor technique. This needs emphasizing strongly because correct administration is a major operation and should be mastered completely before trying this form of treatment. The needle *must* be in the vein before a particle of the remedy is injected and it must not be allowed to get out of the vein during administration. This requires very steady hands, mental calmness and alertness, and conditions under which the patient may be calm and still. Some solutions produce no pain when a little gets outside the vein while some of the most valuable of them produce much pain and may produce sloughing of the skin and tissues at the point of injection; resulting in an aggravating sore, because the tissues cannot dilute the remedy like the blood does under very slow injection—say 5 cc. in three minutes or more. One thing is sure—when we give treatments intravenously we know that the patient is getting what we want to give without any probability of an upset stomach or of the patient setting it upon a shelf and forgetting to take it—a rather common practice.

The blood consists of many elements which have different functions in the physiologic processes which control the life of our bodies. There are various cells, serums, plasma, etc., but the two that I wish to consider in this article are the erythrocytes, or red cells, and the leucocytes, or white cells. In one ucbic millimeter of pure normal blood (an amount smaller that the head of a pin) we find from 4,500,000 to 5,500,000 red cells and from 6,000 to 8,000 white cells. The main function of the red cells is to carry nourishment and oxygen to all parts of the body. When they are interferred with by bacteria, virus, or toxins of various kinds the health of the body becomes poor and death may result. In any of these toxic conditions the quicker we neutralize or eliminate the poisons the better, and my experience, after giving many thousands of such treatments supports the theory, that intravenous medication is the best method by which this may be accomplished.

Salvarsan given by mouth is practically worthless but given intravenously it is one of the best and most extensively used remedies for the treatment of syphilis. It is also good for anemia and for a general toning up of the system. I have given it to many non-syphilitics without letting them know they were getting it, because for years many people believed that intravenous treatments were given only for syphilis.

I usually compare the white cells of the blood to a repair gang. For example, if we break a bone the white cells get busy immediately carrying materials for repair and set to work building new bone to cement the fragments together. If the bone has been properly set and the parts kept at rest it takes only a few days until the break has a cartilaginous splint built around it and the healing soon completed. The greater the movements between the parts the thicker these white cells will lay on the splint; but when the bone is entirely healed and a splint is no longer needed these cells go to work and carry it all away, leaving the bone as it was before the break. In any disease they do the rebuilding and carry off the waste. In many diseases the task is too great for them, then the intravenous method of medication is the best and quickest way to stimulate them. This should be carried out under the most careful selection of the remedy and the employment of a perfect technique.

The original idea for giving salvarsan intravenously was that such a remedy put directly into the blood stream where the germs were found actually killed them by direct contact. This method cannot be over estimated in its value but the great good comes from the increased activity of the fighting processes of the blood—erythrocytosis and leucocytosis. There are some diseases, for example, appendicitis and tuberculosis in which the white cells may be multiplied two or more times their normal number and leucocytosis is said to exist, yet the disease does not abate. In such cases the number increases but their activity is lessened because the horde of abnormal cells become foreign bodies which retard or prohibit the healing processes. Then the intravenous administration of 10 cc. doses of a 1–1500 or 1–1000 solution of hydrochloric acid daily for a week or so will destroy the useless cells and help nature to eliminate them. It also increases the oxygen content of the blood and builds up the powers of the other cells, thus promoting a return to normal activity and recovery. There are other remedies which will produce this increased activity, or phagocytosis—a name given this white

cell activity by Metchnikoff, a noted Russian physician, who discovered it over fifty years ago, but the medical profession was slow to accept Metchnikoff's idea until quite recently. When we give a strong remedy and increase this phagocytosis rapidly we may produce chills and fever. Such a condition is referred to as a protein reaction. I have often produced it purposely because a patient whose temperature is subnormal, or even normal, in some serious disease, is one whose system is making no effort to overcome the trouble. A fever shows the degree of effort a system is putting forth in ridding itself of disease, the higher the heat the better the fight in most cases.

A few weeks ago there was an article in *The American Weekly* which described how blood may be taken from the body and irradiated then returned to the body in the same operation. This method, worked out by Mr. E. K. Knott of Seattle, Washington, and associates, is quite successful in the treatment of various blood poisons, or septicaemias. This "sunshine in the blood," as they called it, puts oxygen carrying ability into the red cells, stimulates and increases the white cells so that many forms of toxins are killed and eliminated. The ultra-violet rays perform their service directly to the blood so act more quickly and efficiently than external applications can do. The difficulty here lies in the fact that the operation is very elaborate and the patient must go to the hospital, making the treatments very expensive. All of the technique of a blood transfusion and more dangers must be considered. The same results may be obtained by the intravenous use of oxygen carrying compounds like the phosphates, or hydrochloric acid and plain H_2O. There are certain remedies which are almost specific in many conditions and the antitoxins produce the same effects while the cost of such treatments is quite within almost everybody's ability to pay.

Several diseases which for many years have been classed as incurable can now be cleared up by intravenous medication at comparatively low cost while the patient goes about his business as usual. There are several prominent physicians who claim that cancer, pernicious anaemia, tuberculosis are curable by this method. In every instance they insist that the patient's general condition must be built up by eliminating all other poisons from the blood and by building up its fighting ability. In such positive diseases and many indefinite conditions we find lassitude, weakness, fatigue, drowsiness, poor appetite, nausea and a decrease

in taste perception, and we often have a marked loss of blood plasma chlorides. As this loss progresses we find mental dullness, muscular cramps simulating rheumatism, and a low blood pressure. This is a clinical entity wherein is good soil for the development of cancer, tuberculosis, leucaemia and other devastating diseases. Here the intravenous use of chlorides is indicated—common physiological salt solution being one of the best. Therefore, to get good results in the treatment of these positive diseases we must take care of the deficiency diseases—nutritional, vitamin and endocrine gland imbalance. In other words, treat the patient as well as the disease. My own experience over a period of twenty-five years of intravenous medication confirms this claim. Many of the more common ailments are lessened in severity and cut short by intravenous medication. For example, orchitis due to mumps, or other infections, required several weeks by the best treatment to ease the pain or reduce the swelling a few years ago. Now a full dose of calcium chloride with an equal amount of sodium salicylate in 10 cc. of distilled water given intravenously will stop the distress in twenty-four to forty-eight hours. Repeated daily for a few doses puts the patient so rapidly toward recovery that he may assume his regular duties in a week or less. If an inflammatory focus is present in the system calcium chloride often locates it because of the intense feeling of heat produced at the time of the treatment—this is especially noticable in the inflamed tissue.

Doctors E. W. Gilbert and C. M. Stewart report in the *American Journal of Medical Sciences* that calcium chloride given intravenously is a real antidote for the bite of the "black widow" spider, giving early and lasting relief from the excruciating pain always present with this venom. It may be given intramuscular with good but slower results in children, but given by mouth it is worthless. This drug will also change a positive test in syphilis to a negative when salvarsan has no effect. It has been one of my best remedies in pernicious anaemia.

A great majority of the cases of high blood pressure, not due to an inflammatory disease of the kidneys or arterio-sclerosis, can be corrected by a short course of intravenous treatments. The blood is purified and returned to normal, bringing the pressure back to normal where it stays.

There are other methods of stimulating the healing powers of the blood—some excellent and some not so good—but I place intravenous medication high in the scale.

TECHNICAL MATHEMATICS IN THE EDUCATIONAL PROGRAM

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In this National emergency of defense it was soon learned that a shortage of trained personnel for the industries existed. The result has been one of the greatest programs for vocational and technical education that we have known. It has brought the schools and industry into close relationship, each getting a better understanding of the others problems. Education, in the future, will benefit from this with technical education receiving the place of prominence that it rightfully deserves.

Today the mechanic is a highly specialized individual in his field. He must work with his head as well as with his hands. He must be master of the tools of his trade and mathematics is one of his tools.

Since, to be effective, mathematics must be taught as it applies to the field of interest, it too must be specialized. Oh yes! the fundamentals remain the same, but the nomenclature, the applications, and the points of emphasis will change to meet the requirements of the field. In all fields drill work must be given to master the fundamentals and ability to think must be developed to make applications to the particular field of interest.

To be specific, I have selected a few illustrative cases from the field of aeronautics to show the extent and quality of the mathematics required. These are not from the engineering courses as you might suspect, but from the first courses in aeronautics that all prospective aero mechanics, technicians, and pilots must take.

(1) Labeling of answers

20″ 20 ft. 20 mi.

100 ft./sec. (or f.p.s.) 100 mi./hr. (or m.p.h.)

18 mi./gal. 0.35 gal./mi.

33,000 ft.-lbs./min. 550 ft.-lbs./sec.

50 pcs

It is just as important to know what units that the answer is in as to know the figures in the answer.

(2) Airfoil characteristics graph (Fig. 1).

This is a combination graph usually involving four things and four vertical scales. It is used to present the airfoil data obtained from wind tunnel tests. One must be fully versed in graph reading and graph interpretation to understand fully the significance of such a graph. Scale reading, decimal fractions, ratio, percentage, and the significance of the negative sign for indicating dimensions are involved.

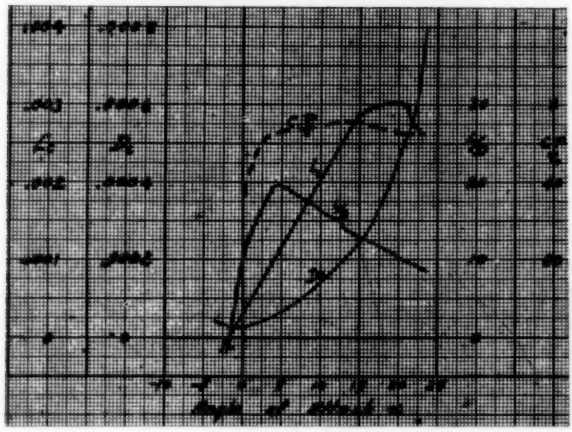

FIG. 1

(3) Formulas

$$L = L_c A V^2$$

L = lift in lbs.

A = wing area in sq. ft.

V = velocity in m.p.h.

L_c = lift coefficient (from graph)

$$\text{Lift} = \text{Weight, then } V = \sqrt{\frac{W}{L_c A}}$$

$$D = D_c A V^2$$

D = drag in lbs.

D_c = drag coefficient (from graph)

$$D_{\text{total}} = D_{\text{wing}} + D_{\text{structure}}$$

$$HP = \frac{D_t V}{375} \qquad HP = \text{horse power required.}$$

These formulas require graph reading, fundamentals of algebra and arithmetic in their evaluation, also they bring out the evaluation of one formula to obtain results for use in another.
(4) Horse power graphs (Fig. 2)

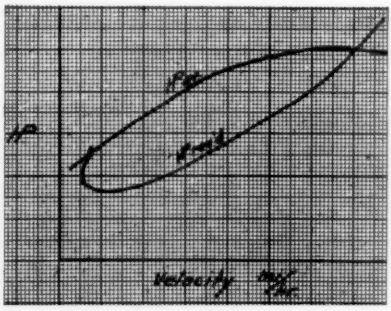

FIG. 2

$$HP_{\text{excess}} = HP_{\text{av.}} - HP_{\text{req'd.}}$$

$$HP_{\text{av.}} = \text{Engine Power} \times \text{Propeller Eff.}$$

$$V_{\text{climb}} = \frac{HP_{\text{av.}} \times 33000}{\text{Wt. of plane}}.$$

Note importance of units HP_{ex} found from the graph.

These graphs are plotted from data obtained by evaluating the HP required formula and from data supplied by the engine and propeller manufacturers. By using data read from this graph the "velocity of climb" formula can be evaluated.
(5) Aircraft repair. (Fig. 3)

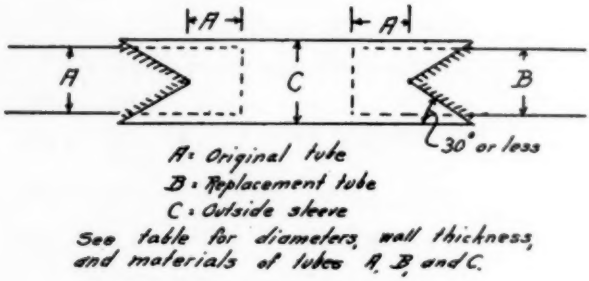

FIG. 3

The Civil Aeronautics Authority specifies standard repair splices. These are given by drawings dimensioned with letters.

The letters refer to columns in tables giving the standard dimensions for the repair of any sized tube.

(6) Mean Aerodynamic Chord for tapered wing. (Fig. 4)

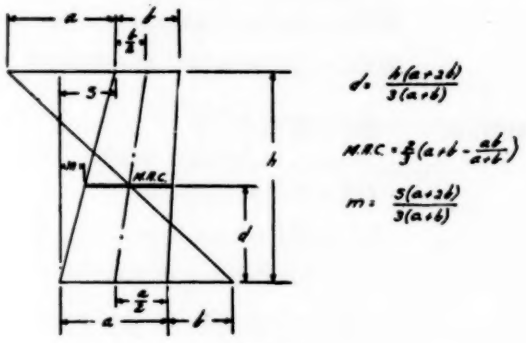

FIG. 4

Many computations and references are made with regard to this chord. Note the geometric construction. A knowledge of geometry and algebra is required if the formulas given are to be derived.

(7) Locating the center of gravity (Fig. 5)

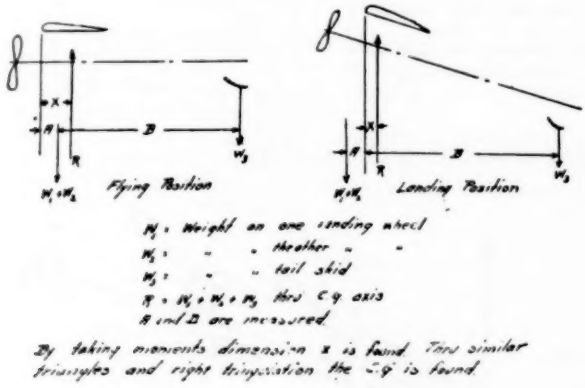
x
A
B
R
W_3
W_1+W_2
Flying Position
Landing Position
W_1 = Weight on one landing wheel
W_2 = " " the other " "
W_3 = " " tail skid
R = $W_1+W_2+W_3$ thru C.G. axis
A and B are measured
By taking moments dimension x is found. Two similar triangles and right triangulation the C.G. is found

FIG. 5

This is required for all planes that have undergone repairs that might have changed the C.G. of the plane. Note the three fundamentals $\sum H=0, \sum V=0, \sum M=0$

(8) Checking propeller pitch (Fig. 6)

Note the use for the right triangle and its solution.

(9) Formulas involving logarithms

Maximum ceiling $$H = 40{,}000 \times \log_{10} \frac{HPa_0 \text{ max}}{HPr_0 \text{ min}}$$

H = ceiling in ft.

HPa_0 = HP available at sea level

HPr_0 = HP required at sea level

Power at altitude $$HP = HP_0 \left(\frac{\rho}{\rho_0}\right)^{1.4}$$

HP = HP at altitude

HP_0 = HP at sea level

ρ = air density at altitude

ρ_0 = air density at sea level

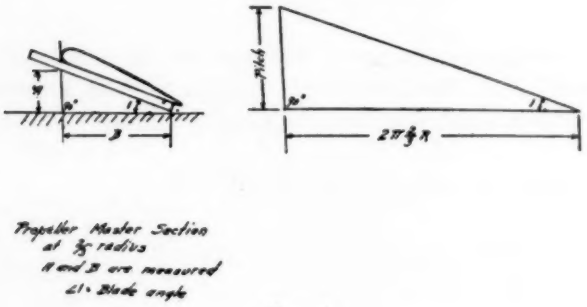

FIG. 6

(10) Air navigation problem (Fig. 7)

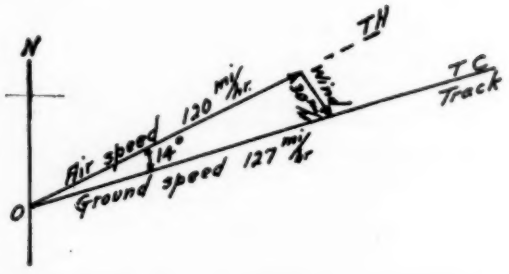

FIG. 7. Illustration taken from "Practical Air Navigation" by Thoburn C. Lyon, *Coast and Geodetic Survey Special Bulletin No. 197.*

Note the addition and subtraction for course correction and the graphical solution (or vector analysis) of the oblique triangle.

55° Compass heading
+ 3° Easterly deviation
58° Magnetic heading
− 6° Westerly variation
52° True heading (TH)
+14° Drift (measured from vector diagram)
66° True course (TC track)

In the field of aeronautics the slide rule can be used to advantage. Enough practice should be given on it to instil confidence and efficiency in its use.

Thus, in a brief space allotment, I have tried to show the place that mathematics occupies in the field of aeronautics. Since, from the nature of the work in this field there can be no compromise with safety, the individual must be thoroughly trained in fundamentals and above all else accurate in his work.

DON'T WORRY ABOUT SUN EXPLODING

If you have ever been worried about exploding stars—the "novae" or "new" stars that suddenly flash out thousands of times brighter than they were before and have been afraid that the sun might some day blow up in a similar manner, your fears are unjustified.

According to Dr. Dean B. McLaughlin, of the University of Michigan Observatory here, stars that become novae seem to be quite different from the sun. They are about 80,000 degrees F. in surface temperature, or eight or nine times as hot as the sun, about a tenth of the sun's diameter, and some 200 times as dense. Though their surface brightness is greater than that of the sun, their total light is somewhat less, because their smaller globes have less surface to shine. On the whole, believes Dr. McLaughlin, it seems as if such stars were pretty much the same before the outburst as they are later, when the effects of the explosion are over.

Even scientists have false ideas about the pre-explosion state of these bodies. In a recent issue of *Science*, Dr. McLaughlin called attention to a recent book on the sun and its source of energy, in which it is stated that a spectrum photograph of one nova before outburst showed characteristics very similar to those of the sun.

This Dr. McLaughlin denies. The only nova for which a pre-explosion spectrum was obtained appeared in the constellation of Aquila in 1918. Studies showed, he says, that its spectrum "was definitely not of solar type."

He traces the incorrect statement to certain conjectures about Nova Herculis, which flashed out in December, 1934. These were never confirmed.

CHEMISTRY FOR THE CONSUMER

I. The Chemistry of Foods

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In constructing a science curriculum, major importance should be given to those science topics which are most often needed in solving the common problems of everyday life. No topic is more closely related to public welfare than a knowledge of the importance of proper food consumption. In this article an attempt has been made to summarize those elementary principles of chemistry relating to foods which might be appropriately included in an elementary course in chemistry. These principles are briefly outlined in the following digest:

The Functions and Classification of Foods

1. Foods serve three functions in the body; namely, to yield energy for maintaining body temperature and for muscular work, to build or renew body tissues, and "to regulate the body processes and internal conditions so as to maintain the right environment for life."
2. The important nutrients required by man are fats, carbohydrates, proteins, vitamins, water, oxygen, and mineral salts.

The Composition, Sources, and Uses of Foods

1. Fats are esters of fatty acids and glycerin, composed of the elements carbon, hydrogen, and oxygen. Butter, meat fats, olive oil, cottonseed oil, corn oil, wheat germ oil, peanut oil, soya bean oil, etc. are examples of edible fats. In the body fats may be utilized as a source of energy, stored in modified or unmodified form, converted into necessary cell tissues, or excreted as such in the feces.
2. Carbohydrates are substances composed of the elements carbon, hydrogen, and oxygen in which the hydrogen and oxygen are in the same proportion as in water. Starch, sugar (sucrose, maltose, lactose, glucose, and fructose) are familiar examples of carbohydrates. Grains, cereals, and potatoes are foods rich in carbohydrates. Aside from serving as a fuel, carbohydrates may be temporarily stored as glycogen or transformed into fats.
3. Proteins are very complex substances composed of carbon, hydrogen, oxygen, nitrogen, sulphur, and sometimes other

elements such as iron, phosphorus, etc. Examples of proteins are albumen of the white of eggs, casein of milk, and gluten of wheat. Meat is a good source of protein. Milk, eggs, cheese, legumes, nuts, and fish are also rich in protein, and may replace the meat in the diet. Proteins are utilized in the body as fuel or to build body tissues.

4. Vitamins are accessory substances present in food in small quantities that are essential to the normal functioning of the body and for the prevention of disease. They are organic substances of varying compositions. Up to the present time, five vitamins, A, B_1, C, D, and G(B_2) are known to play an important part in human nutrition. (16)
   a. The fat-soluble vitamin A is found in milk, eggs, butter, etc. A lack of vitamin A in the diet results in a widespread weakening of the body in its ability to resist diseases. This vitamin is not a preventative or a cure for common colds.
   b. The water-soluble vitamin B_1 is found in yeasts, cereals, etc. Nervous disorders result from a deficiency of this vitamin in the diet. Extreme deficiencies of vitamin B_1 lead to beri-beri, a disease confined largely to the Orient.
   c. Citrous fruits are the best natural sources of the water-soluble vitamin C. It may also be obtained in pure form as ascrobic acid. Sufficient amounts of vitamin C must be included in the diet in order to prevent scurvy which lowers body resistance.
   d. Sunshine, codliver oil, and halibut oil are convenient sources of the fat-soluble vitamin D. Vitamin D is one of the essential factors in the prevention of rickets. A deficiency of vitamin D and a low or unbalanced intake of calcium and phosphorus are the dietary defects responsible for rickets.
   e. Milk and yeast are good sources of the water-soluble vitamin G(B_2) which is essential to growth and normal nutrition. Vitamin G also appears to be one of the factors in the prevention of pellagra.
5. Water provides for the transportation of food throughout the body, assists in the regulation of body temperature, serves as a vehicle for waste, and assists in the chemical changes of digestion and other life processes.
6. Oxygen is essential for the combustion of foods and the consequential release of energy. With the exception of oxygen,

most of the inorganic elements enter the system as mineral salts, and are derived from the ash or mineral parts of our food. In general these substances,

a. Aid in bone and teeth formation to which they give strength and rigidity.
b. Aid in the control of the heart and other muscular contractions.
c. Assist in regulating the water content of cells and blood plasma.
d. Serve as raw materials for vital secretions.
e. Help to prevent an acid condition of the tissues.

7. Calcium and phosphorus assist in regulating the functions of muscles, nerves, and internal fluids, and are essential constituents of the bone, muscle, and teeth. Calcium is the inorganic element most apt to be deficient in the average American diet. The amount of this element included in the diet conditions, to some extent, the amount of phosphorus a person needs and uses. "With a low intake of calcium, excess of phosphorus may produce serious disturbances in the way of acidosis and other physiological effects." Milk, egg yolk, whole grains, and green vegetables are rich in calcium and phosphorus.
8. Iron is necessary for building red blood corpuscles. Nutritional anemia usually results from a deficiency of iron. The formation of hemoglobin, however, not only required adequate amounts of iron, but also sufficient amounts of copper. Copper has nothing to do with the assimilation of iron, but functions in the conversion of inorganic iron into organic iron. Fruits, vegetables, egg yolk, red meats, and glandular organs such as liver, kidneys, etc. are high in iron content. Prunes and raisins are particularly rich in iron.
9. Iodine is essential in small amounts for the proper functioning of the thyroid glands. Goiter is a dearrangement of the thyroid glands due to overactivity in an attempt to prepare the necessary amount of thyroxin in the absence of sufficient iodine. Green vegetables, whole cereals, and some sea foods are rich in iodine. The presence of iodine in the proportion of 0.01% in table salt will prevent goiter.
10. Chlorides are important as a source for the hydrochloric acid of the stomach, and sodium and potassium salts play an important part in regulating the osmotic action taking place between the cells and lymph.

Measure of Food Values: Fuel Values

1. A calorie is the unit used for measuring the amount of heat energy and energy value of foods. This unit is used for expressing the energy value of foods because man obtains the energy necessary for maintaining a constant body temperature, muscular activity, etc., by the combustion of the food he eats.
2. The fuel value of those organic nutrients which release energy when oxidized is determined by means of a bomb calorimeter.
3. The fuel requirements of humans may be determined by direct measurement of the heat liberated or by observing the oxygen intake and the carbon dioxide output. The basal or minimum requirement for the average person is from 1,500 to 1,700 calories per day. This basal rate is influenced by age, surface area, glandular and nervous activity, sex, body temperature, and specific dynamic action.

Balance of the Diet

1. A proper balance is as important as caloric value in the selection of an appropriate diet.
2. The determining factor of the protein requirements is not the amount of protein but the kind and amounts of amino acids supplied by the protein. An appropriate diet should contain adequate amounts of a complete protein. A complete protein is one which supplies all of the amino acids necessary for sustaining life, such as those of milk and eggs. Meat and fish also contain proteins of good quality. If the right forms of proteins are consumed, one-tenth of all the calorie intake should be protein. The consumption of excessive amounts of protein seems to be toxic and produce putrefaction in the large intestines.
3. A minimum of from ten to fifteen per cent of the calorie intake should consist of carbohydrates in order to prevent ketosis, a condition similar to diabetes.
4. If the protein and carbohydrate requirements are taken care of, the rest of the daily calorie requirements may be supplied by fats. Fats have the highest fuel value of all the foods consumed by humans. They are digested more slowly than carbohydrates or proteins, but this does not disturb the active healthy person.
5. The vitamin and mineral requirements are extremely small,

and may be expressed in milligrams. In most cases human requirements of these nutrients can be supplied once a day or once a week. In all cases, except sulphur, the minerals may be supplied in either organic or inorganic form.

6. The average person should drink from six to eight glasses of water a day. The presence of minerals containing calcium, phosphorous, iron, and iodine in drinking water is beneficial. The presence of appreciable amounts of fluorine and silicon is harmful.
7. The diet should include foods which provide appropriate amounts of some form of bulk such as wheat bran or any cereal, vegetable, or fuits containing cellulose. This material aids in the digestion and absorption of the other food elements by stimulating the peristaltic action of the intestines, and the prevention of constipation due to stagnation or a lack of bulk.

Digestion of Foods

1. Digestion is the process of converting food from the form in which it is eaten into a soluble and diffusible form which the body can absorb and utilize. This process involves both chemical and physical changes.
2. Most of the chemical changes taking place during digestion are induced by substances secreted by living cells called enzymes. The action of enzymes is specific, and they apparently bring about the decomposition of food molecules into simpler substances by catalytic hydrolysis.
3. Food is broken up into smaller particles and thoroughly mixed with the digestive fluids by mastication and the peristaltic action of the stomach and intestines.
4. Fats, carbohydrates, and proteins undergo digestion, while minerals and water are taken directly into the blood stream.
5. In the small intestines the fats are hydrolyzed into fatty acids and glycerine through the aid of steapsin, a fat splitting enzyme of the pancreatic juice. The bile, an alkaline secretion of the liver, assists in breaking up the fat particles into fine globules of an emulsion, thereby exposing a very large total surface of the fat to the action of the enzyme. The alkali present in the bile converts the fatty acids into soluble soaps. The soaps and glycerol are absorbed into the blood, resynthesized into fats, and transported to points of use or storage.

6. The digestion of carbohydrates begins in the mouth with the action of pytalin, the enzyme of the saliva, which converts cooked starch into maltose. The digestion of carbohydrates is completed in the small intestines through the action of amylopsin, the enzyme of the pancreatic juice which acts on starch in any form, and the three invertases, sucrase, maltase, and lactase, the enzymes of the intestinal fluid. Glucose, the end product of the digestion of carbohydrates is absorbed into the blood stream and subsequently oxidized to yield energy, converted into fats, or stored in the liver as glycogen.
7. The digestion of proteins begins in the stomach where they are coagulated and broken down into simpler molecules by the enzymes pepsin and rennin. In the small intestines the enzymes trypsin and erepsin bring about the complete decomposition of proteins into amino acids. The amino acids are absorbed from the digestive tract and later resynthesized into complex body proteins which are used to build up the cells.

Effect of Heat on Foods

1. When fats are burned or over-heated they form glycerin which is, in turn, decomposed forming acrolein, an irritating and poisonous gas.
2. Cooking increases the digestibility of starch because heat causes the cells of which it is composed to burst open, thereby exposing them more directly to the action of the digestive juices. Toasting bread converts the starchy matter into a more easily digested substance, dextrose.
3. Vitamins A, G, and D are only slightly affected by heat, Vitamins B_1 and C are destroyed by oxidation which is hastened by heat.

Selection of an Appropriate Diet

1. The appetite is not a safe guide to food requirements. A person's age, weight, and degree of activity should determine the quality and quantity of food required.
2. An adequate diet must include,
   a. Sufficient amounts of organic nutrients in digestible form to yield the needed energy.
   b. Proper proportions of digestible carbohydrates.
   c. Sufficient amounts of a complete protein.

d. Adequate amounts and proper proportions of the various mineral elements.
e. Sufficient amounts of vitamins A, B_1, C, D, and G(B_2). (7)
f. Sufficient amounts of the proper forms of bulk.

3. A strict vegetarian diet should be avoided because it is apt to be deficient in vitamin D and calcium and contain incomplete proteins. A strictly meat diet is low in carbohydrates.
4. Milk, our most nearly perfect food, is deficient in iron, copper, manganese, and vitamin C and usually low in vitamin D. "Normal children should consume a quart of milk a day, normal adults a pint, together with a well-balanced supplementary diet, which in the case of children should include such foods as orange juice, codliver oil, and green vegetables." (10)

Dietary Disorders

1. The effects of an inadequate diet are not always self-evident, but sometimes take a long time to manifest themselves.
2. Obesity results from the consumption of too much food and too little exercise, or disturbances of the glands of internal secretion. It is a menace to health, burdensome, and contributes to fatigue and body discomfort. Persons suffering from obesity should reduce sanely and safely. All efforts at weight reduction should be carried out under a physician's direction through the aid of a carefully planned diet and suitable exercise. (15)
3. Deficiency anemias are due to a lack of iron, copper, proteins, or vitamins. A milk diet, mineralized with iron and copper, will supply all of the materials needed for building hemoglobin. (3)
4. Many individuals are upset when they eat, breathe, or touch substances which are harmless to the average normal individual. This abnormal behavior is known as allergy. It may be produced by an ingredient of some common food, drug, or cosmetic, hairs, pollens, bacteria, feathers, or, in some isolated cases, by almost any substance. Common examples of allergy are "hay fever and asthma due to pollens or dust, hives and dermatitis from strawberries, citrous fruits, or shellfish."

5. "Acidosis is a rather rare condition of the blood; it is not a common disease because the normal body has the necessary mechanism for disposing of excess acids and alkalies. There is little need for worrying if the diet is reasonably well balanced." (14)
6. Diabetes results when the body is unable to utilize carbohydrates due to a lack of insulin, a hormone secreted by the pancreas. Its symptoms are a loss of weight and strength, constipation, and excretion of large quantities of water. Persons suffering from diabetes should have a special diet and insulin treatments under a competent physician's direction.

Food Fads and Fancies

1. There is no scientific basis for most food fads and fancies. As a rule, they are based upon personal idiosyncrasies. (14) The acid or alkaline balance of a normal person cannot be changed by any one food or combination of foods. Fasting does not remove poisons from the system or improve the health of an individual. Prolonged fasting causes an organism to feed on itself.

Preservation and Adulteration of Foods

1. A suitable temperature, water, oxygen, and food are four conditions essential to life. The methods of food preservation are usually based upon denying the organisms which bring about the decomposition of foods one or more of these factors.
2. The recognized methods of food preservation are desiccation or dehydration, smoking, pickling in vinegar, sugar preservation, heat treatment (pasteurization, sterilization, etc.) and low temperature refrigeration. Smoking preserves foods because various tarry products such as creosote are distilled from woody materials when they are burned in insufficient air. These substances have germicidal properties. A refrigerator preserves food by keeping it dry and cold.
3. Foods may also be preserved by the use of antiseptic chemicals. The use of antiseptic preserving materials is objectionable, however, for
   a. They make it possible to use foods that have already undergone decomposition.
   b. They retard or otherwise interfere with the digestive processes.

c. They exert a toxic effect on the human system.

4. Some of the recognized forms of food adulteration are admixture, substitution, abstraction, imitation, preparation of foods from diseased, contaminated, filthy, decomposed, tainted or rotten materials, concealment of damage or inferiority, and the addition of substances which are poisonous, injurious or deleterious to health. The various forms of food adulteration may be encountered singularly or in combination. (20)

Chemistry of Special Foods

1. Milk is composed of milk sugar (lactose), butterfat, milk proteins (casein, lactalbumin, and lactoglobin) which completely meet the body protein requirements, vitamins A, B_1, and G(B_2), and minerals. The principle inorganic elements in milk are calcium, phosphorus, iron, copper, potassium, sodium, magnesium, chlorine, sulphur, and iodine. (20)
2. Butter is one of the most unstable fats. It easily gives rise to rancidity and has a high coefficient of digestibility. Process or renovated butter is made by melting or reworking rancid butter into a product resembling fresh butter.
3. Cheese is a highly concentrated protein food, consisting roughly of equal parts of milk proteins, fat, and water. Desirable flavors are produced in cheese by salt and microorganisms.
4. Oleomargarine is the term commonly applied to butter substitutes. These substances are usually mixtures of beef fat and cottonseed oil. Sometimes a small amount of butter is added to give them the flavor of butter.
5. The term oil generally applies to the glycerides, essential oils, and mineral oils.
   a. The glycerides are esters of fatty acids and glycerin. Chemists usually refer to the solid glycerides as fats, and the liquid ones as oils. These substances are of vegetable origin. They are non-volatile, saponifiable and differ widely in composition. Practically all glycerides are soluble in fat solvents, insoluble in water and cold alcohol, and slightly soluble in hot alcohol. Then too, they are poor conductors of heat, possess a high heat value, and turn rancid when acted upon by atmospheric oxygen, especially in the presence of light and moisture. (9, 13)
   b. The essential oils are mixtures of hydrocarbons of the

type $C_{10}H_{16}$ and various alcohols, aldehydes, ketones, esters, phenols, etc. These substances are volatile, non-saponifiable, and usually very soluble in alcohol and slightly soluble in water. They form the basis for most natural perfumes and flavoring materials.

c. The mineral oils are mixtures of hydrocarbons, usually paraffin hydrocarbons. They are non-volatile, non-saponifiable, and non-digestible. Petroleum is the chief source of these substances which may be solid, soft, or liquid, depending on the number and kind of hydrocarbons of which the mixture is composed.

6. Olive oil is the most widely consumed vegetable oil. It is produced in several grades. The highest grade is Virgin olive oil which is characterized by a "golden tinge and a decided fruity taste." (9) Refining reduces the quality of olive oil. Sometimes olive oil is misbranded or adulterated with cheaper oils. Sesame oil is less expensive than olive oil, and could replace it for many purposes.
7. The chief nutritive quality of white bread is its caloric value. It consists essentially of starch, gluten, and a small quantity of sugar. It is low in calcium and iron, deficient in vitamins, and supplies an incomplete protein.
8. Coffee and tea have no nutritional value. Boiling tea extracts tannic acid from the leaves. This acid extraction can be reduced to a minimum by steeping the leaves.

Suggested Activities

Demonstration Experiments
- The Principle of the Calorimeter
- Fermentation of Molasses
- Analysis of Foods
  - Ash constituents
    - Copper—oysters
    - Iron—oysters, blueberries, spinach
    - Calcium and phosphorus—milk
  - Detection of water, carbon, hydrogen, and nitrogen in foods
- Hydrolysis of Starch by Acids
- Halphen's Test for Cotton Seed Oil

Classroom Experiments
- Test for Organic Compounds
- Chemistry of the Body
  - Hydrolysis of starch by enzymes
  - Hydrolysis of proteins by enzymes
- Chemistry of Fats
  - Detection of the presence of fats in foods
  - Spot test to distinguish between glycerides and essential oils

Foam test to distinguish between fresh butter, margarine and renovated butter
Preparation of acrolein from fats
Chemistry of Carbohydrates
Detection of the presence of carbohydrates in foods
Preparation of caramel
Preparation and properties of dextrin
The production of dextrin from starch by toasting bread
The relations of sugars, acids, and starches to the ripening of fruits
Proteins
Detection of the presence of proteins in foods
Extraction of casein from milk
Preparation of casein adhesives
Separation of gluten from wheat

Testing Foods for Preservatives and Adulteration

Analysis of foods for chemical preservatives—sodium benzoate, benzoic acid, salicylic acid, formaldehyde, and sulphur dioxide
Analysis of foods for substitutions—starch, saccharin, glucose for cane sugar, etc.
Analysis of foods for artificial coloring (acid dyes)

Projects

Supplementary Experiments
Preparation and analysis of the common types of baking powder
Qualitative test for alcohol in foods
Separation of milk into its components
Separation of essential oils from natural sources by steam distillation
Patch test for allergy—Apply some of a suspected product (food, drug, or cosmetic) to a sensitive part of the skin, cover it with gauze, and allow it to remain for 24 hours. At the end of this period, look for any signs of an irritation or eruption.
Models, Posters, and Exhibits
Construction and demonstration of a model of a respiratory calorimeter
An exhibit showing the composition, sources, and uses of the various nutrients needed by man
The Chemistry of Digestion, an exhibit showing the important chemical changes taking place in foods at various points along the digestive tract, together with the organ secreting the enzymes which aid in bringing about these changes
The Acid-Base Balance, an exhibit showing how to maintain the proper acid-base balance in the diet
The Daily Water Balance, a poster showing the sources of the daily water intake and the amounts and points of water intake and excretion
How Alcohol Affects the Body—an exhibit showing the importance of alcohol as a food, and as a narcotic and its therapeutic usefulness and value
Written Exercises
An essay explaining the main provisions and deficiencies of the Federal Food, Drug, and Cosmetic Act
Obtaining pertinent information on foods, drugs, and cosmetics—Require the students to clip a number of advertisements of food products, drugs, and cosmetics from the daily newspaper or magazine or compile a list of these items used in the home and submit this material to the instructor or someone placed in charge who

eliminates all duplications. Then have each student write to the American Medical Association on from three to six of the remaining items, and present his replies to the entire class. Inquiries on "patent medicines," quacks, medical fads, and various other phases of pseudo medicine should be referred to the Bureau of Investigation. Requests for information relating to foods and the acceptability of their advertising claims should be sent to the Council on Foods. A similar procedure may be followed in reference to materials and devices used in connection with oral hygiene. Information on these topics may be obtained gratis from the Council on Dental Therapeutics of the American Dental Association.

Sources of Information

1. American Dental Association, The Secretary, Council on Dental Therapeutics, 212 East Superior Street, Chicago, Illinois.
2. American Medical Association, Bureau of Investigation and Council on Foods, 535 North Dearborn Street, Chicago, Illinois.
3. Better Business Bureau, Inc., Chrysler Building, New York City.
4. Evaporated Milk Association, Chicago, Illinois.
5. Food and Drug Administration, U. S. Dept. of Agriculture, Washington, D. C.
6. General Foods Corporation, Consumer Service Dept., 230 Park Ave., New York City.
7. Household Finance Corporation, 919 N. Michigan Avenue, Chicago, Illinois.
8. Metropolitan Life Insurance Co., New York City.
9. Vitamin Products Co., Milwaukee, Wisconsin.

Bibliography

1. Bogert, L. J., *Nutrition and Physical Fitness*, 3rd ed., W. B. Saunders Co., Philadelphia, 1939.
2. Bridges, M. A., *Food and Beverage Analysis*, Lea and Febiger, Philadelphia, 1935.
3. *Building Hemoglobin with Iron plus Copper in Nutritional Anemia*, Wisconsin Alumni Research Foundation, Madison, Wis., 1937.
4. Cannon, W. B., *The Wisdom of the Body*, rev. and enlarged ed., W. W. Norton and Co., Inc., New York, 1939.
5. Carpenter and Hann, "Food for Children," *U. S. Dept. of Agric., Farmers' Bul. 1674*, 1931, Supt. of Docs., Washington, D.C.
6. *Digest of the Federal Food, Drug, and Cosmetic Act*, Food and Drug Administration, U. S. Dept. of Agric., Washington, D.C., 1938.
7. Fiene and Blumenthal, *Handbook of Food Manufacture*, The Chemical Publishing Co., Inc., New York, 1938.
8. *Food Fats and Oils*, Household Finance Corporation, Chicago, 1937.
9. Frank, L. C., "What Every Person Should Know about Milk," *U. S. Public Health Service Supplement 150*, Supt. of Docs., Washington, D.C.

10. HARAP, H., *The Education of the Consumer*, The Macmillan Co., New York, 1924.
11. HORTON, R. E., *Laboratory Manual in Chemistry*, D. C. Heath and Co., New York, 1927.
12. JAMIESON, G. S., "Vegetable Fats and Oils," *Monograph Series*, American Chemical Society, Chemical Catalog Co., New York, 1932.
13. MITCHELL and COOK, "Facts, Fads, and Frauds in Nutrition," *Bul. 342, Massachusetts Agric. Exp. Station*, Amherst, Mass., 1937.
14. *Overweight and Underweight*, Metropolitan Life Insurance Co., New York.
15. REYNOLDS, M. S., "How We Can Get Our Vitamins," *Special Circular*, Extension Service of Col. of Agric., Univ. of Wis., Madison, Wis., 1936.
16. ROSE, M. S., *Foundations of Nutrition*, rev. ed., The Macmillan Co., New York, 1933.
17. SHERMAN, H. C., *Chemistry of Food and Nutrition*, 5th ed., ibid., 1937.
18. WOODMAN, A. G., *Food Analysis*, 3rd ed., McGraw-Hill Book Co., Inc., New York, 1931.
19. *Wisconsin Department of Agriculture and Markets Bulletin—189*, Wis. Dept. of Agric. and Markets, Madison, Wis., 1938.

COURSES FOR TEACHERS IN THE PHYSICAL SCIENCES AT THE UNIVERSITY OF CHICAGO

During the Summer Quarter the University of Chicago is offering two courses for persons interested in the teaching of integrated courses in the physical sciences at the senior high school and junior college levels. These courses acquaint teachers with the subject matter of an integrated course, its organization and methods of presentation. They are accepted for professional requirements (education) and for the Divisional Master's degree in the Physical Sciences. The material will be interchanged in the First and Second Terms of successive summers. These courses will be given by members of the Physical Sciences staff in cooperation with the Board of Examinations and the Department of Education. They will not be offered if fewer than 25 students register, so that, if you are interested, write early to Prof. Stephenson, at the Physical Sciences Office. These courses are described below.

Physical Sciences 294. An Integrated Course in the Physical Sciences for Teachers of High School and Junior Colleges. The content of this course is essentially the same as in the one-year Physical Science General Course in the College, but the level of mastery required is higher than in the latter. Opportunity is given for participation in presenting lectures and in conducting discussion sections. The First Term includes the following topics: molecular and atomic nature of matter, the chemical reaction, oxidation and reduction, atomic structure and chemical behavior, carbon compounds geologic processes, weather and climate, and history of the earth. The Second Term covers mathematics as a tool, mathematics as a science, matter and energy, heat, electricity, radiant energy, the solar system, the sidereal universe. 2 C's. (or 1 C. either Term). 9:00–11:00, Stephenson and Staff.

Physical Sciences 295. Problems in the Teaching of Integrated Physical Science Courses in High School and Junior College. Open to those students only who are enrolled in Physical Sciences 294. Problems relating to the determination of objectives, organization of materials, methods of presentation, and the methods and techniques of examination will be discussed. C. or (1/2 C. either Term). 11:00, Ashford and Staff.

A SIMPLE DEMONSTRATION BALANCE AND SOME OF ITS APPLICATIONS

WALTER A. THURBER

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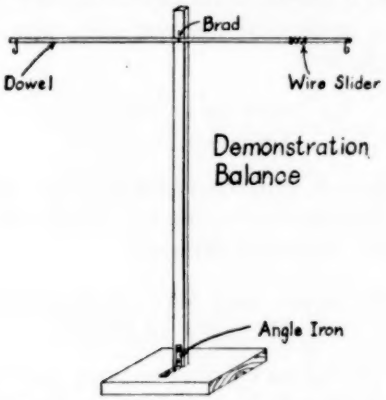
On some occasion every science teacher, whether he be in the grades, in the high school, or in college, needs a demonstration balance. To meet this need, there is described below an inexpensive balance that is surprisingly sensitive, and can be used effectively in the largest lecture room. Among its other virtues is the fact that it costs less than ten cents to make and takes less than ten minutes to build.

Even in schools owning expensive demonstration balances, this device has its uses. Because of its simplicity, it does not dis-



tract attention during the introductory stages of problem solving. Many teachers make science seem unnecessarily abstruse by using complex apparatus before the need for such apparatus is apparent.

The diagram shows the details of construction. The beam is a quarter-inch dowel, thirty inches long, bought at a lumberyard or cabinetmaker's. The upright is about thirty inches long and the base is about a foot square. Exact dimensions are not significant. The angle iron can be bought at a five-and-dime store.

The hooks are made of #24 copper wire. A spiral of wire serves for a rider. Loops of wire may be used as counterbalance weights. The writer has found no need for further refinements.

Following are some of the demonstrations for which the balance is suitable.

To Show that Air Has Weight

Inflate a toy balloon and tie its mouth with a string, using a bow knot. Hang the balloon from one hook by piercing the loose rubber at the mouth. Bring to a balance. Pull out the knot, steadying the balance until the air has escaped.

To Show that Heated Air is Lighter than Cold Air

Hang a five-pound paper sack bottom upward, from one hook. This can be done by attaching a loop of thread to the bottom of the sack with a piece of tape. Bring to a balance. Hold a candle or other source of heated air beneath the sack, steadying it until the air in the sack is warmed. Remove the source of heat and release the sack. If the air in the sack is allowed to cool, the beam will reassume a horizontal position. The warm air can also be emptied from the sack.

To Show that Hydrogen is Lighter than Air

Hang a small sack, bottom upward, from one hook and counterbalance it. Produce hydrogen in a bottle and hold the bottle beneath the open mouth of the sack.

To Show that Carbon Dioxide is Heavier than Air

Hang a two-pound sack from one hook and bring to a balance. Produce carbon dioxide in a flask and pour the gas in the sack. After the sack has descended it may be emptied by inverting it, after which the beam will become horizontal. The demonstration may be enlivened by hanging a sack from each hook and filling them and emptying them in turn.

To Show that Carbon Tetrachloride Is Heavier than Air

This demonstration is similar to the one above on carbon dioxide. A little carbon tetrachloride in a flask may be vaporized by the heat of the hand.

To Show that Water Evaporates from Cloth

Wring out a piece of cheesecloth in water and hang over a wire suspended from one hook. Bring to a balance. In a short time the cloth will be much lighter.

To Show Sublimation

Dry ice will sublimate so rapidly as to make bringing to a balance difficult.

Camphor ice will sublimate appreciably in an hour, especially if broken up.

To Show the Effect of a Breeze on an Inclined Surface

Thumbtack a card to one end of the balance. The card should be at about a 45° angle with the horizontal. Bring to a balance. A very slight breeze from front or back will elevate or depress the card.

To Show Buoyant Effect of Water

Suspend a rubber stopper from one hook using a long thread. Bring to a balance. Raise a jar of water up beneath the stopper.

To Show that Depth and Size of a Vessel Does not Affect the Buoyant Effect

Repeat the above demonstration, but use vessels of different depths and volumes. A long cylinder may also be used to show that buoyancy is not appreciably greater near the bottom than near the top.

To Show that Substances in Solution Affects the Buoyancy of Water

Suspend a stopper from one hook by a thread. Immerse the stopper in water and bring to a balance. Add salt, sugar, or alcohol to the water and notice the effect on buoyancy.

Oil poured on the water will not mix or dissolve, of course, but by lowering the vessel until the stopper is immersed in the oil, the buoyant effect of the oil may be compared with that of water.

To Show that Carbon Dioxide is More Buoyant than Air

Inflate a rubber balloon, and suspend it from one hook. Bring to a balance. Prepare a large quantity of carbon dioxide in a large battery jar or aquarium. Acid and soda in the bottom of the jar will provide the gas. Bring the jar up under the balloon. The buoyant effect will be marked during the first few moments. However, the carbon dioxide diffuses into the balloon and counteracts part of the buoyant force.

To Show that Carbon Dioxide Diffuses through Rubber

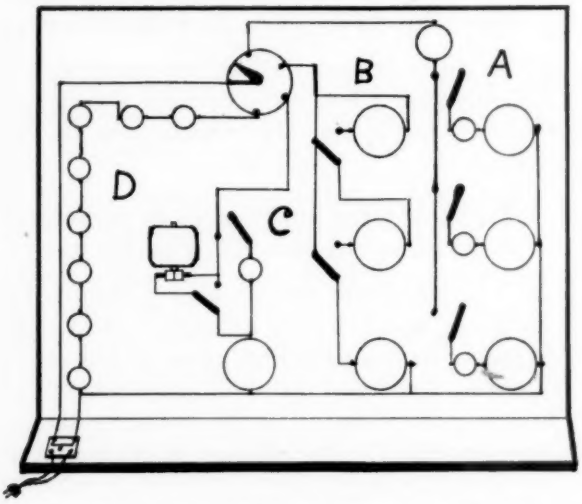
This demonstration is much like the preceding one. The balloon is left suspended in the carbon dioxide for about a minute. Then, when the jar of carbon dioxide is taken away, the balloon will be found to be much heavier.

RESISTANCE DEMONSTRATION ASSEMBLY

F. W. Moody
Cleveland High School, St. Louis, Missouri

Here is a demonstration board of slightly different type, for pointing out the relative values of resistances and currents in parallel and series combinations.

It consists of four circuits operated separately from a four point switch from the regular 110 volt outlet.



Circuit A comprises three 110 volt lamps of 60, 100, and 120 watts, either of which may be lighted separately. Or else two, or all three may be operated together in parallel. In the circuit of each lamp is placed a miniature three volt lamp whose brightness depends on the size of the other lamp. In the main circuit is inserted a six volt automobile lamp capable of carrying the current through all three lamps. The brightness of this lamp serves as a gauge to show the increase in current as one, two, and three lamps are turned on in succession.

To eliminate the dazzling effect, each of the large lamps has been given a coating of Duco paint, and to emphasize the fact that they are of different wattage, each is painted a different color. The paint is not dense enough to hide the glowing filaments but does give a better opportunity for judging the brightness of the small lamps.

Circuit B comprises three 40 watt frosted tungsten lamps which may be operated with one lamp alone on the 110 volts, or with two in series, or with all three in series. The successive dimming of the lamps as one, two, and three are used, gives an idea of their increasing resistance and the corresponding reduction in current.

Circuit C consists of one 120 watt lamp which may be put in series with a three volt lamp, or with a small motor, or with the two in parallel. This is to show how a small motor may be operated from a 110 volt line.

Circuit D contains eight 15 volt lamps in series as operated on the "Christmas Tree" circuit.

All the switches except the large four point switch, are mounted on the back of the panel with wires running through. The whole thing may be operated from the rear without reaching over to interrupt the view of the class, and it is always ready for display without a single change in the connections other than the turning of the switches. It is supported vertically on a five inch base requiring little case room and is low enough to easily fit in between the shelves.

CURRICULUM WORKSHOP INFORMATION

Place—Cornell University, Ithaca, New York
Director—Professor M. L. Hulse, College of Education
Length of Term—6 weeks, July 7 to August 15, 1941
Tuition Fee—$60.00 for the session
Total number of credits possible to earn in the Workshop during the six weeks—6

The Workshop is designed for teachers in the elementary and secondary schools. The cooperating divisions are English, social studies, science, mathematics, home economics and agriculture. Members of the Education and Arts staff at Cornell will share with members of the Workshop the responsibility for developing projects relating to the teaching of democracy. This theme is stressed because teachers are under pressure to make a greater contribution toward the attainment of this goal. To insure a realistic approach the Cornell Workshop staff is surveying the needs of a representative central school in up-state New York. The faculty of this central school later will attend the Workshop to carry forward plans for reorganizing the school curriculum.

MATHEMATICS OFFERED TO COMMERCE AND ADMINISTRATION STUDENTS IN JUNIOR COLLEGES

W. H. Clark

Gage Park High School, Chicago, Illinois

The amount and kind of mathematics offered junior college students of commerce and administration have been a matter of interest for years. The amount of mathematics required of students in all courses has decreased so much recently that it was deemed desirable to know what the situation was in commerce and administration courses at this time. Observation gave the impression that not many schools required mathematics of such students. In addition it was believed that a certain amount and type of mathematics would be beneficial to commerce and administration students. Therefor this investigation was undertaken.

Method of Investigation

At the outset of this investigation books and school magazines pertaining to the subject were carefully studied. One would almost believe there was a prohibition against writing on the subject. After being convinced that there was little to be found from such sources, Junior College catalogues were consulted. It is apparent that they are a primary source of information. The information was not 100% complete because many schools have no such announced courses and others that did have commerce and administration courses made no statement of the mathematical requirements. From that situation the conclusion may be drawn that many school administrators do not consider mathematics a necessity.

The source of the catalogues used was the Educational Library of the University of Chicago. The inspection was made easy through the courtesy and assistance of the librarians. The catalogues were shelved in files by states. In each file was found all the school catalogues which the University has received. Some of these catalogues dated back to the 90's. The first task was to select the last catalogue received from each state. Not all junior colleges had catalogues on file, not all junior colleges offered commerce and administration courses, and not all were clear on their course requirements. Also, in looking over such a vast number of catalogues errors and omissions could be made.

It might be of interest to know that there were 435 files and many catalogues in most of the files, and all states were represented. Not much was lost because of these difficulties. Considering also the uniformity of the data obtained not much better results could have been secured.

One striking matter was noticed in the investigation of these catalogues and that is the large number of junior colleges that offer commerce and administration courses that have no mathematical requirements. This was particularly true of private junior colleges. There may have been over 200 such school catalogues that showed no required mathematics in the commerce and administration curricula. Also there was a large number of junior colleges that made no statement, except that mathematics was required. This also was true of private junior colleges. The paucity of offerings of any kind in commerce and administration courses in junior colleges was very noticeable. Again this was more generally the case with private junior colleges. It is surprising that many schools can be accredited with such meagre offerings.

Of the several hundred catalogues inspected only 169 offered information on the subject of mathematical requirements that was usable in this paper. The dates of the catalogues inspected ranged from 1930 to 1938. The number for each year was as follows:

1930–1	2	1933–4	5	1936–7	37
1931–2	2	1934–5	13	1937–8	61
1932–3	4	1935–6	9	1938–9	33

In each case the latest catalogue was consulted. These data are mentioned to show that the catalogues are of recent date.

The junior college catalogues in the University of Chicago Educational library came from all the states and were filed by states, the largest number, of course, being from the state of California. The catalogues were inspected for the type of mathematics desired for this investigation. In the catalogues this type fell under such headings as General Business, Business Administration, Business and Public administration, Secretarial courses, Commercial courses, Commercial curriculum. Commerce and Finance but they all came under the meaning desired.

Names of Courses

The names of the mathematics subjects required for the com-

pletion of the commerce and administration courses were as follows:

Commercial arithmetic
Commerce algebra
Business arithmetic
Algebra
College algebra
Intermediate algebra
Trigonometry
Plane geometry
Solid geometry
Analytical geometry
Business statistics
Applied algebra
Commercial mathematics
General mathematics
Solid analytical geometry
Differential calculus
Statistical methods
Statistical and graphical representation
Elementary statistics
Business mathematics
Problems of finance
Unified mathematics
Mathematical analysis
Commerce and finance
Theory of investment
Mathematics of finance
Personal finance
Investment finance
Mathematics preparatory to statistics and finance
Mathematics and investment
Corporation finance
Mathematical introduction to statistics
College arithmetic

Here are enumerated thirty-three distinct names of courses.

It appears that these headings can be reduced to a smaller number. For example, commercial arithmetic, business arithmetic, business mathematics. and commercial mathematics might be much the same type of mathematics. All those courses mentioning statistics might fall into one group. The content of the course would depend on the ideas of the instructor and possibly on the clientele served. The Chaffey Junior College curriculum in commerce calls for business statistics and business mathematics. Included in the latter are logarithms and arithmetical and geometrical progressions. This is one of the very few cases in which logarithms are mentioned. The Junior College of Los Angeles does not teach logarithms. However, they are introducing a new course entitled Mathematics of Finance.

In 37 schools business mathematics of some kind was required; in seven schools analytical geometry was specified. In many schools mathematics was elective. In fourteen schools mathematics, or science, or a language must be elected. The Los Angeles Junior College requires only business arithmetic. The text used is somewhat on the order of a work book and is compiled by the faculty. Logarithms are not presented and hence the formulas for compound interest, etc. can not be used. The book contains many pages of interest tables. The argument is that bankers use such tables for their computations.

Thirty schools require mathematics of finance of some kind.

Most of such schools also require some other kind of mathematics, such as commercial arithmetic, etc. Thirty-seven schools require algebra of some level, elementary, intermediate, or college. Most of the schools that require algebra of some kind have also other mathematical requirements. Seventeen schools require trigonometry. Just what connection there is between trigonometry and a commercial education is difficult to conceive.

Some schools simply require a mathematical elective. Attention was paid to the published curricula of the Junior Colleges to see what that mathematics elective might be. In most cases the elective could not include mathematics closely related to the commerce and administration curricula because commerce and administration mathematics was not there. This situation was found in smaller schools. The amount required was from one to four semesters. Many schools that did require mathematics, and named the courses, mentioned a type of mathematics that was not related to commerce and administration curricula; e.g. college algebra, trigonometry, analytical geometry, solid analytical geometry and calculus. However, some schools permitted a mathematical elective. In several cases the mathematics, if elected, was specified.

In addition to the above considerations concerning mathematical requirements for commerce and administration students in Junior Colleges many schools gave good training in money and banking, banking, auditing, and economics which of themselves are forms of mathematics and partake of the nature of mathematics. Pasadena and Fullerton commerce and administration students do the banking and auditing of all students' accounts plus various items of administrative business such as book store, cafeteria, and other sundry accounts. Fullerton also carries checking accounts for their students. In the case of these two cities the annual amounts run into huge figures. The data on the mathematical training thereby obtained is impossible to estimate from catalogues.

Entrance Requirements for Commerce and Administration Students

Those junior colleges that mentioned their requirements for entrance to the commerce and administration courses most frequently mentioned one year of algebra and one year of geometry. One school mentioned two units of mathematics; two schools mentioned three units; and one school, two years of

mathematics. The smaller private junior colleges ignored entrance requirements although they may have had some. Many of the private junior colleges had their own preparatory schools.

E. Justin Hills[1] sent out a questionnaire to 131 junior colleges in the United States concerning titles of mathematics subjects open to freshmen. He divided the questionnaire into various parts. The particular question which pertains to this study was mathematical courses of an occupational character open to commerce freshmen. Eighty schools replied with the following results as pertaining to commerce and administration students:

Name of Subject	*Schools*
Mathematics of Finance	24
Statistical methods	4
Business mathematics (terminal courses)	3

These figures are somewhat of the same order as those obtained by inspection of junior college catalogues. Mathematics of finance had the highest score. This is undoubtably due to the fact that it is the mathematics course required of precommerce students. Hills says that for students entering Junior College with only two years of high school mathematics intermediate algebra is suitable for them and for precommerce students since it must precede mathematics of finance, frequently the only mathematics course in their college curriculum. Hills' article recommends an abundance of mathematics for preparatory senior college students, but not much for terminal college students. The same idea is obtained from other educational writers.

L. J. Adams[2] made a brief analysis of the mathematical courses in 26 California junior colleges ranging in student enrollment from 100 to over 4000 students. The number of semester courses offered varied from three to twenty-two. He enumerated a typical offering as consisting of elementary algebra, intermediate algebra, elementary plane geometry, plane trigonometry, solid geometry, plane analytical geometry, differential and integral calculus, solid analytical geometry, and infinite series. He said that outside of the above core, mathematics of finance is the most popular course. This last statement agrees with the above junior college school catalogue investigation and with Hills' statement.

Adams concludes that the objectives of any particular mathe-

[1] Hills, E. Justin, Compton Junior College, SCHOOL SCIENCE AND MATHEMATICS, November, 1929, p. 880.

[2] Adams, L. J., *Junior College Journal*, Vol. 7, p. 194, Jan., 1937.

matics department must be in harmony with the objectives of the junior college of which it is a part, and they, in turn, depend on the needs of the community which the junior college serves.

SUMMARY

This brief investigation set out to ascertain what was the most desirable type of mathematics to be taught commerce and administration students in junior colleges. An inspection of the courses in junior college catalogues indicates that mathematics of finance was the most frequently offered to commerce and administration students, and statistics of some kind was the next most frequent offering. The investigation of Hills and Adams covering over 100 junior colleges coincides with the above conclusion. The curricula of junior colleges of considerable size did offer these two courses. Many small public junior colleges and private junior colleges offered only business mathematics of a lower grade than mathematics of finance and statistics.

SCIENCE BOOKS

The publication of books on science and technology has shown a steady increase in the United States for the last decade according to statistics compiled by the Bureau of the Census.

The year 1939 thus far marks the peak of production for publishers of books on scientific and technological subjects with a total of 3,432,642 volumes. Figures for that year are the latest available, since the Census of Manufactures, covering production in all American industries, is taken only biennially. The next Census, to be conducted in 1942, will cover 1941 production.

The 1939 total represents an increase of more than a million volumes over the 1937 total of books on science and technology, 2,380,351 volumes.

Separate statistics on production of books on science and technology have been compiled by the Census Bureau biennially since 1925. They are:

1935—1,937,084	1929—2,294,660
1933—1,611,642	1927—2,392,044
1931—1,818,585	1925—2,094,343

ELECTRIC TRAFFIC CONTROL FOR FISH

A traffic-control device for fish is the object of patent 2,233,045 granted to F. S. Bonner of Kootenai, Idaho, and M. R. Miller of Huntington Park, Calif. It consists essentially of a gate-like structure which is placed athwart the stream or irrigation ditch from which the fish are to be barred. Contact of the fish's body with bars of the gate turns on an electric current, not strong enough to kill or harm it, but delivering just enough of a shock to make said fish lose interest in going in that particular direction.

THE PUPIL INITIATED PROJECT IN HIGH SCHOOL PHYSICS

M. J. W. PHILLIPS
West Allis High School, West Allis, Wisconsin

Modern educational procedure is assumed to take into account the individual interest of the child, to find his interest, and to hold it while he is learning. Science furnishes the teacher many opportunities for this type of work.

Leading educators have discussed the "project method" at intervals since 1900. It is discussed by Kilpatrick,[1] as follows: "The particular word, project, as here used, is of small consequence; the idea or point of view back of the word is the important element. We understand the term project to refer to any unit of purposeful experience, any instance of purposeful activity, where the dominating purpose is an inner urge, (1) fixes the aim of action, (2) guides its process, and (3) furnishes its drive, its inner motivation."

Professor Kilpatrick further distinguishes four types of projects as follows: "The first type represents those experiences in which the dominating purpose is to do, to make, or to effect; to embody an idea or inspiration in material form. . . . The second type of project may be defined as one which involves purposeful enjoying or appropriation of an experience. . . . The third kind of project is one in which the dominating purpose is to solve a problem, to unravel and so compose some intellectual entanglement or difficulty."

Many project procedures follow the plan of suggested lists of projects; lists furnished by the teacher, lists collected in schools of education. These then become a list of "busy work" problems, many of which make the child feel that he is not contributing much to the class of which he is a member, or to the science which he is studying.

The writer feels that the pupil many times carries out a project to satisfy the teacher, rather than to learn some scientific principle. The best project is that initiated by the pupil as the result of reading some book, or for the purpose of solving some problem that has been in his mind for some time, or for making clear to the class some assigned topic or part thereof. Pupils, sometimes, without any instruction, assistance, or suggestion on

[1] Kilpatrick, William H., *Source Book in the Philosophy of Education* (Macmillan Company, 1926), Chapter XX, The Problem Method, pages 318–321.

the part of the teacher, select and carry through to completion, activities of this kind. This type of project, the state of mind of the pupil, and his school surroundings are discussed by Douglass.[2]

Douglass says: "The project as used in teaching is a unit of activity carried on by the learner in a natural and life-life manner, and in a spirt of purpose to accomplish a definite, attractive, and seemingly attainable goal. . . . One of the outstanding characteristics of the American high school pupil is the lack of any impelling motive to work. The classroom activities of the typical high school student appear anything but purposeful or absorbing. . . . The project is a good example of a definite assignment—*one self-assigned*. A second reason for increased interest and effort is the fact that the purpose is the student's own. He does not approach the task under duress or compulsion. . . . . Another source of the interest provoking project work is the fact that it engages some of the most powerful natural drives of human conduct—the craving for achievement, the desire for self-expression and self direction, the desire for manipulation and construction, the desire to know and to settle states of doubt and uncertainty, the so-called instinct of curiosity, and the desire for the approval of one's achievement."

Three illustrations of pupil initiated projects, and the circumstances under which the pupil created them, are given here. Photographic illustrations of each are shown.

I. Home-made Sextant

The boy who initiated this activity read a book while in the eighth grade. This book discussed ships and navigation, and gave a description of the use of the sextant. He had made models of ships, some crude, others fairly good. He decided, while still in the eighth grade, that he wanted a sextant for his own use, and the best way to get one was to make it. He then set about to make one. He looked at pictures of sextants in books, visited places where sextants were sold to look at them, and talked with men who know how to use sextants, or those who actually used them.

After he had collected what he thought was all the needed information, he set about to organize this toward the construction of the instrument. He made a pattern for the main frame of the

[2] Douglass, Harl R., *Modern Methods in High School Teaching* (Houghton-Mifflin Company, 1926), Chapter XI, Project Teaching, pages 325–329.

sextant; from this pattern he made a mould and cast the frame, himself, of a soft "white" metal. After four years of planning at intervals and a sustained interest, he completed the instrument here illustrated. (Fig. 1)

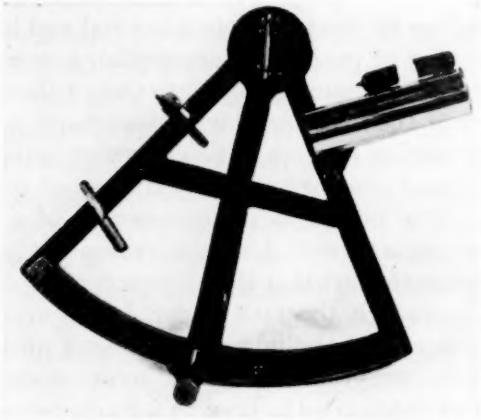


FIG. 1. Home-made sextant.

It is crude as sextants go, but he learned how to use a set of tables found in his geometry book involving the use of the sextant. He certainly encountered many difficulties that required solution. The training given him by this project was shown when he displayed the instrument to a physics class, a mathematics class, and before a science club. His recitation was of the interest holding nature that is so lacking in the formal recitation that takes place in the science classroom under average good teaching conditions.

II. HOME-MADE SPECTROSCOPE

The fact that light possessed certain properties and that the spectroscope from light alone could reveal different kinds of matter appealed to the boy who initiated this project. He announced one day to me, after class, "I am going to build a spectroscope." I tried to discourage him somewhat as that type of activity, if attempted, would be quite difficult to do, but he insisted, and I am pleased that he did insist. Our school had at the time only a small hand type spectroscope; other than that, he had never seen one. He had no plan or anything other than pictures in physics textbooks and encyclopedias. Using the pictures as models, he carved out in his home shop a set of patterns

of wood. The illustration shows the set of patterns and castings made from them, all done in his basement work shop. The castings were cast from aluminum. Since the metal is of low melting point, it could be melted in the fire pot of the home heating plant, and the castings poured right there. He encountered plenty of failure in making the castings, especially the moulding portion. The project served to illustrate the value of "stick-to-it-iveness," the end of which is success. All he had to buy was a fifty cent prism from a scientific supply house, a good toy telescope that was given him for Christmas by his parents. This boy had to collect his own ideas, materials, and organize them without any teacher assistance or counsel.

The completed spectroscope is shown in Fig. 2 together with patterns and rough castings. One cannot imagine with what anticipation and real interest this boy looked forward to the successful completion of this instrument. As a matter of fact it

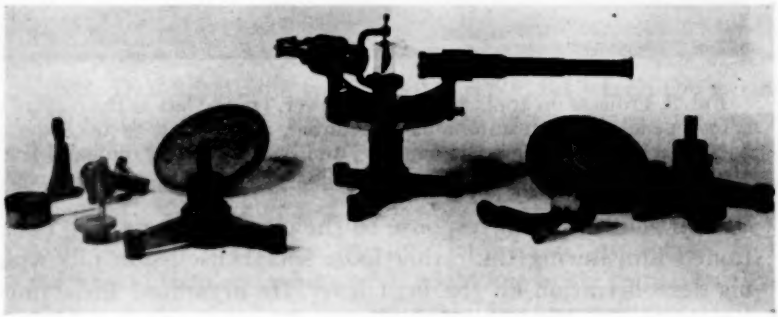


FIG. 2. Pupil made spectroscope. Wood patterns on the left of the completed spectroscope, the unfinished aluminum castings from these patterns on the right.

functioned quite well; and when the boy was called upon to demonstrate it to the physics classes and before the science club, he held the attention of his listeners, as well or better than a good science teacher. He was making a contribution and explaining it at his own level; that always commands wholehearted attention. This project also served to inspire other pupils to undertake activities of a similar nature.

III. LEVER APPLICATIONS

Fig. 3 illustrates three levers of types much in use, two from the automobile—foot pedal and emergency brake—and the claw hammer. The pupil who initiated the project was a boy of aver-

age ability, who had shown difficulty in reciting or assisting with demonstrations before the physics class. He also seemed to have an unsavory attitude toward the teacher and physics work, in fact, toward nearly all school work. He was called upon to recite, demonstrate and solve problems relative to the lever. He attempted to make clear to the class that portion of lever study where a portion of a lever arm is considered twice. He said,

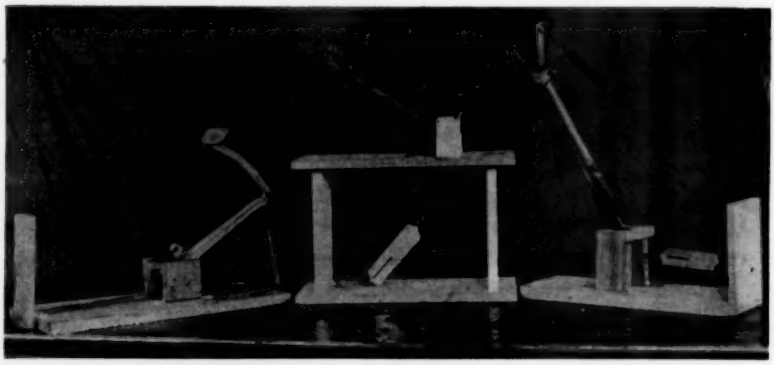


FIG. 3. Projects on applications of the lever. On the left in the picture is a foot pedal from an automobile, mounted, and drilled to take spring balances. In the center is the hammer, and on the right is the hand lever of the emergency brake of the automobile.

"I will show you" in response to the class members who questioned him during the rather loose social discussion following his demonstration on the bent lever. He organized these projects himself—simple as they are—and brought them to school carefully wrapped and concealed from other pupils. He brought the package to the instructor as soon as he arrived in school. When he unwrapped it, he delivered as fine a recitation on levers, right then and there, as the writer had ever heard. This boy's interest in physics, in fact his interest in all school work, improved materially. The project, though simple to construct, was selected and organized entirely by the student without direction from anyone. He does have an interest in automobiles.

The attention given by the physics classes to the pupils who do this type of work, and the questions asked during the discussion periods, indicated that this type of project selection, when it occurs, does have a wholesome learning effect, not only on the part of those who do this type of work, but also on the part of those who see it and hear it.

SHORT CUTS AND APPROXIMATIONS IN CALCULATIONS

J. P. HARPER
University of Scranton, Scranton, Pennsylvania

I. *Introduction.* The amount of labor so many put up with in arithmetic computations is surprising, especially when a result is desired correct to only three or four digits. The tedious process of doing multiplications, divisions and roots "long hand" is not at all necessary for obtaining answers to problems in arithmetic, algebra, physics, etc., after the processes have once been well fixed in mind. By the time a student begins trigonometry in high school, and certainly when he begins college mathematics, he should be able to do his computations rapidly and accurately and not have to spend all of his time on the arithmetic and thereby defeat the purpose of the problem. Further than this the student should by this time be able to take advantage of certain shortcuts in arithmetic. This is especially the case when the answers need be correct to only three or four digits. In determining roots, for example, (of which the author has written before)[1] the answers are rarely required to more accuracy than is obtained by one of the simple approximation methods, so that it is a waste of time and effort to employ the arithmetic method. It is regrettable to see students carrying out a division or multiplication by "long hand" to ten or more places and then scratching off the last five or six since a suitable answer could have been had by employing an intelligent approximation with less than one third the time and effort.

The methods herein presented cover the subjects of multiplication and division. Although more accurate results are obtained by logarithms the operations outlined for the simpler problems in multiplication and division can be done more rapidly with a little practice and require no tables. Also the accuracy is sufficiently high to recommend it to teachers and students for classroom computations in trigonometry, algebra, chemistry and physics. Of course, when a problem involves numerous multiplications and divisions in one step it would be advisable to use logarithms as repeated applications of approximation operations would likely give an accumulated error.

In pursuing what follows it is well to keep in mind that it is

[1] J. P., Harper, "Approximate Square and Cube Roots," SCHOOL SCIENCE AND MATHEMATICS, April, 1939.

the number and value of the digits involved which determine what the answers are going to be and that the position of the decimal point does not at all affect the operations performed. It would be of advantage to take care of the decimal point in the beginning before the actual computations are made. This can be done by the use of the exponential 10. As an example 345/2.39 would be considered as $(345/239)\times 10^2$, then 345 would be divided by 239, and for the final result this quotient would be multiplied by 100.

To become adept at using the methods presented here one must be able to make an intelligent guess. He must be able to guess the answer roughly to two digits. This is not such an impossible assignment as it seems especially if one reduces the numbers involved by a digit or so. In the example cited above one could obtain a rough two-digit answer by considering the fraction to be 36/24, which is 1.5. It may happen that the second digit is not correct but as it happens it does not greatly matter if it is out by one point one way or another.

II. *Short cuts in division.* It might be well to mention a few of the short cuts commonly used in division as an introduction into the subject of approximation division. (a) In dividing a number by 25 one simply moves the decimal two places to the left and multiplies by 4. (b) To divide a number by 50 the decimal is moved two places to the left and the number is multiplied by 2. (c) When dividing a number by 75 consider it 3×25, divide by the 3 and then by 25 as in (a). (d) To divide a number by 125 consider it as 5×25, divide the number by 5 then proceed as in (a). (e) A similar thing can be done for any of the multiples of 25 and 50. (For example, to divide a number by 150, considering $150 = 3\times 50$ divide the number by three then by 50 as in (b)). (f) Division of numbers by factors (from 2 to 12) of the divisor $\left(\text{for example } \frac{383}{35} = \frac{383}{5\times 7} = \frac{76.6}{7} = 10.943\right)$. There are many more that might be mentioned but these are most widely used and are well known.

III. *Approximation division.* Ordinarily to divide a number of three or more digits by another such number and to obtain an answer with three or more digits in it requires the "long hand division" or the use of logarithms. If it is desired to obtain the answer correctly to only three or four digits it can be done by an approximation more quickly than by logarithms, but if it is

necessary to have the answer to more places then the "long hand" method or logarithms will be necessary.

The basis of the approximation division of one number by another number of more than one digit is briefly this: Decrease or increase the denominator so that it becomes a number easily divisible into the numerator, or so that it becomes factorable into numbers which can be divided into the numerator, and at the same time decrease or increase the numerator in proportion. Suppose one had the fraction $X=M/N$ and that each of the numbers M and N, or at least N, consisted of three or more digits. One would first increase (or decrease) N until it became a number easily divisible into the numerator. But the numerator would have to be increased (or decreased) by a similar amount. Let the increase in N be a and the increase in M be b,

then
$$\frac{M}{N}=\frac{M+b}{N+a},$$

from which
$$M(N+a)=N(M+b),$$
$$Ma=Nb,$$

and
$$b=\frac{M}{N}a.$$

Finally, $X=\dfrac{M+\left(\dfrac{M}{N}\right)a}{N+a}$. ($a$ may be either $+$ or $-$ and is relatively small in comparison to N.) This is what may be called the approximation division formula.

Before one can find b the quotient M/N must be known, but since $M/N\times a$ will be a small number in comparison to M, only a rough value of M/N is necessary. To obtain a rough two digit value of M/N one may round off the numbers to two digits.

The accuracy of the division formula is therefore determined by the accuracy with which we get the rough value of M/N and by the smallness of the value a. Ordinarily a need never be as much as 10% of N as $N+a$ can always be made to have some small values or single digit factors without using a large value of a.

Consider some examples of division worked out by means of the approximation division formula above, a being as small a percentage of N as possible.

Example I. Find $X=\dfrac{796}{343}$.

Let $X=\dfrac{796+b}{350}$, where $a=+7$ (2% of 343).

To find b: $\dfrac{796}{343}=\dfrac{80}{34}\doteq 2.4$, then $b=2.4\times 7=16.8$.

Now, $X\doteq\dfrac{796+16.8}{350}=\dfrac{812.8}{70\times 5}=\dfrac{11.61}{5}=2.322.$

The actual value rounded off to four digits is 2.321. The error is about .05%. In working this problem it would not actually be necessary to write down so many numbers. It could be done as shown below.

$$X=\frac{796}{343}=\frac{812.8}{70\times 5}=\frac{11.61}{5}=2.322;\quad \begin{cases} a=7 \\ b=\dfrac{80}{34}\times 70=2.4\times 7\doteq 16.8. \end{cases}$$

The values of a and b could be put down to the side or could be obtained mentally.

Example II. Find $X=\dfrac{736}{.00645}$. This can be written

$$X=\frac{736}{645}\times 10^5.$$

Now let $X=\dfrac{736+b}{640}\times 10^5$ (where $a=-5$);

$$b\doteq\frac{74}{64}\times(-5)\doteq -1.16\times 5\doteq -5.8.$$

Then $X=\dfrac{736-5.8}{640}\times 10^5=\dfrac{730.2}{8\times 80}\times 10^5$

$$=\frac{9.128}{8}\times 10^5=1.141.$$

The actual value of X is 1.141 correct to four digits.

Example III. Find $X=\dfrac{4.35}{782}$.

Rearranging we have $X=\frac{435}{782}\times 10^{-2}=\frac{(435+b)}{800}\times 10^{-2}$, $(a=18)$.

The rough value is $\frac{44}{78}\doteq .56$ and $b=18\times .56=10.08\doteq 10.1$.

Then
$$X=\frac{435+10.1}{800}\times 10^{-2}=\frac{445.1}{800}\times 10^{-2}$$
$$=.5564\times 10^{-2}=.005564.$$

The actual value is .005563 when rounded off to four digits. This has a relatively small percentage of error.

For the three examples given above it is seen that the method usually gives answers correctly to less than .05%. Of course, the effectiveness of the method depends upon the accuracy with which one can guess the first two digits of the answer and upon the rapidity with which one can do the calculations involved. Unless most of the calculations are done mentally the method will not be any faster than the usual arithmetic method.

The method above applies just as well to a case where the divisor is a four digit number.

Example IV. Find $X=\frac{2190}{3146}$.

Let $X=\frac{2190}{3146}=\frac{2190+b}{3200}$, $(a=54)$, and

a rough value of X is $\frac{22}{32}\doteq\frac{11}{16}\doteq .7$, and $b\doteq 37.8$.

Now, $X=\frac{2190+37.8}{3200}=\frac{2227.8}{80\times 40}=\frac{27.846}{40}=.6961.$

The correct answer (to four digits) is also .6961.

IV. *Short cuts in multiplication.* There are several worthwhile and often used short cuts in multiplication that might be mentioned briefly in any discussion on the subject of multiplication.

(a) Multiplication by factors. Example

$$64\times 13=8\times 8\times 13=8\times 104=832.$$

(b) Multiplication where the multiplier is increased or decreased to a simple number and a correction is made afterwards. Examples:

$$38\times63=(40-2)(63)=2520-126=2394;$$
$$205(392)=(200+5)(392)=78800+1960=80{,}760.$$

(c) Multiplications by numbers such as 25, 50, 75, etc. To multiply a number by 25 move the decimal point two places to right then divide by 4; to multiply a number by 50 procedure is same except the division is by 2; 75 may be considered as 3×25, so that first the number is multiplied by 3 and then the result is multiplied by 25 as indicated above.

(d) A less common method of multiplying two digit numbers together consists in shortening up the long hand multiplication to a single step. Example: 29×37. According to usual method one would write

$$\begin{array}{r} 29 \\ 37 \\ \hline 203 \\ 87 \\ \hline 1073 \end{array}$$

But it is not necessary to write down the products 203 and 87, for one can proceed in this way

$$\begin{array}{r} 29 \\ 37 \\ \hline 1073 \end{array}$$

$7\times9=63$, write down the 3 under the 7 and carry the 6; then multiply 7×2 and 3×9, add these and the 6 to get 47, put down the 7 under the 3 and carry the 4; finally multiply 3×2 and add in the 4 to get 10, the last two digits of the answer. Thus we arrive at the same answer much more quickly and with less writing. This method applies very well to the squaring of two digit numbers. Example: $29^2=841$. (Square 9, get 81, write down 1 and carry 8; multiply 9×2, double and get 36, then add the 8 getting 44, put down 4 and carry 4; square 2, get 4, add in 4, get 8 and write down 8; result 841.)

(e) The squaring of three digit numbers can be accomplished very quickly by the method where one number is increased or decreased to a convenient multiplier and the other is decreased by the same amount and the amount of increase and decrease squared is added to the product of the other two. Example I.

$$374^2 = 400 \times 348 + 26^2 = 139200 + 676 = 139{,}876.$$

[Proof: $374^2 = \{(374+26)(374-26)\} + 26^2$

$= (374^2 - 26^2) + 26^2 = 374^2$]

Example II. $943^2 = 900 \cdot 986 + 43^2 = 887400 + 1849 = 889{,}249.$

All of the methods outlined above are valuable to anyone who does a great amount of calculation but requires use before they can be of any real advantage.

V. *Approximation multiplication* (of two numbers consisting of three or more digits where the answer is desired to only three or four digits). The method consists of reducing or increasing one of the numbers to a convenient number and increasing or decreasing the other number by a corresponding amount. Let $X = MN$, and let the increase in N be a and the decrease in M be b. Then

$$X = MN = (M-b)(N+a)$$

and

$$MN = MN + Ma - bN - ba$$

$$b(N+a) = Ma,$$

this gives

$$b = \frac{M}{N+a} \times a.$$

Then $MN = \left(M - \frac{M}{N+a} \times a\right)(N+a)$, is the approximation multiplication formula. The approximation comes in to the extent that b is in error or has been approximated. Of course if a is negative then b is positive. As in the case of approximation division the value of $N+a$ need not be an even hundred but can be any number which has small factors (from 2 to 12). Let us consider a few examples to see to what extent the method may be relied upon.

Example I. Find $X = 319 \times 242.$

Let $X = (319-b)(250)$, where $a = 8.$

$$b = \frac{M}{N+a} \cdot a = \frac{319}{250} \cdot 8 \doteq 1.3 \times 8 = 10.4.$$

Then $X = 308.6 \times 250 = 77{,}150.$

The actual value is 77,198. The error is about .06%. The error in the answer results from the approximation in the ratio of $\frac{M}{N+a}$.

Example II. Find $X = 486 \times 727$.

Let $X = 500(727 - b)$,

where $a = 14,\ b = \frac{727}{500} \times 14 \doteq 1.45 \times 14 \doteq 20.30.$

Then $X = 500(727 - 20.3) = 500 \times 706.7 = 353{,}350.$

The actual value is 353,332 and the error is 28 or about .01%.

Example III. Find $X = .3675 \times 281.6$.

Rearranging we have $X = 36.75 \times 28.16 \times 10^{-1}$.

Let $X = (36.75 + b)(28)$,

where $a = .16,\ b = \frac{36.75}{28} \times .16 \doteq 1.3 \times .16 \doteq .208.$

Then $X = (36.75 + .21)(7 \times 4) \times 10^{-1}$

$= 3.696 \times 7 \times 4 = 25.872 \times 4 = 103.488.$

The actual answer is 103.488—there is no error in this case. It might be mentioned here that one could have considered this product as 3675×2816 and could have placed the decimal after having obtained the numerical answer.

I have found that approximation multiplication and division is of sufficient accuracy (with a little use) for many computations and can be made to save a great amount of time. It should be of great value to students of algebra, trigonometry, chemistry and physics. Furthermore it gives the students a chance to guess the answer to their problems. This is something that they should always do (but do not frequently do) before actually determining the answer. I believe that many teachers may also find the approximation methods discussed above of great value to them in the classroom for working out illustrative examples.

MAGNET OPERATES SEWING MACHINE

A novel type of sewing machine, invented by Frederick Diehl of Elizabeth, N. J., is covered by patent 2,232,692. In the conventional type of sewing machine the needle bar is driven up and down by means of a rotating shaft extending through the head of the machine. In Mr. Diehl's invention, this is accomplished by making the needle bar part of an electro-magnetic system. It is surrounded by a solenoid or hollow coil magnet, which raises and lowers it as rapidly as the current changes direction in the coils. Rights in the patent are assigned to the Singer Manufacturing Company.

MAN'S RELATION TO THE LAND[1]

BRUCE L. MELVIN
Work Projects Administration, Washington, D.C.

The welfare of any society, whether it be industrial or agricultural, is ultimately determined by the relation of the families in the society to the land. Our American democracy is largely a child of the soil, and the final test of this democracy will be determined, I believe, by the relation that men and women finally come to bear to the space of the earth on which they live whether they be urban or rural dwellers. The welfare of the person who works the soil for a living is conditioned by the fertility of the soil, the technology used in farming operations, and his legal relation to the farm. The welfare of the urban dweller is likewise determined by his relation to the land though the cause and effect may not be so readily observable. The welfare of the city, however, is conditioned largely by the way the city as a composite entity uses its land and the manner in which it exploits its hinterland.

The challenge to America today is to save democracy from external aggressions of totalitarianism and from the consequences of increasingly aggravating internal conditions. Among the most grievous of these conditions is the maladjustment of both the rural and urban families to the land. As an hypothesis it may be stated that political issues, economic problems and even wars may be little more than the rumblings of fundamental changes. These changes are frequently in the separation of an increasingly larger proportion of the population from the land and the attempt of the people to readjust to the conditions created by the exhaustion of the soil itself. Accordingly, forming the backlog of this discussion are two ideas: (1) that man's well-being depends on the soil and (2) that America's defense must be made within her borders by finding the proper relation of man to land.

Maladjustments of man and land have destroyed civilizations in the past; it is possible that they may do so again. Moreover these maladjustments prevail in both rural and urban territory and manifest themselves in different ways. America's danger from within is such that some thinkers are asking just what

[1] Paper read at the Ecological Section of the meeting of the American Association for the Advancement of Science, Dec. 27, 1940.

does America have to defend in so far as the future is involved. Pictures from the past show part of this danger.

The Land and Civilization

Nations and peoples have arisen on the strength of their virgin soils and fallen with their exhaustion. Countries in which this appears to have been true include China, Syria, Trans-Jordan, North Africa, our own Southwest, Greece, Italy and Peru. A few details about part of these only can be given.

The birthplace of Chinese civilization is in Northwest China in the loess soil region. The Yellow River, the name of which signifies erosion, reveals the story of decadence. The wastage of land in China has resulted in wide areas of bad lands, periodic droughts and destructive floods.[2] In speaking of this country, Dr. Walter C. Lowdermilk says: "The staggering soil wastage of North China is unbelievable. Historical records show that the mountain slopes of North China were once heavily forested. Population increased and exceeded the carrying capacity of the alluvial valleys, thereupon the farmers cleared away the forests and pushed civilization farther and farther up the slopes. Trees were cut, fertile soils were dug up and planted to crops. In from three to twenty years, depending on the gradients of the slopes, the soils were washed off and farmers abandoned these fields to clear new lands."[3]

North Syria has an even more revealing story to tell. This is the land of dead cities and desert lands. Among the cities are those about which we have heard since childhood: Antioch, Aleppo, Palmyra. The area is called the graveyard of cities; an area of past prosperity and opulence. Here evolved a local civilization with a distinctive Syrian art such as is found in no other place. The development was brought to a sudden end in the early part of the seventh century when the Persians first and the Arabs a little later, overran the country, killed the inhabitants and blotted out their culture. In so doing they destroyed the vineyards, as well as the cities, and with these perished even the traditions of careful agriculture. Thirteen centuries have elapsed and with their passing has gone the soil; a once fertile

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[2] See: Lord, Russell, *To Hold the Soil*, Miscellaneous Publication No. 321, United States Department of Agriculture, 1938, p. 21.

Jacks, G. V. and Whyte, R. O., *Vanishing Lands*, New York, Doubleday, Doran and Co., Inc., 1939, pp. 80 and 81.

[3] In *American Forests*, January, 1940, p. 14.

country is now a desert, man made.[4] Antioch, as an example of decline, at one time had some 400,000 population, now has only some 28,000, including a garrison.

Trans-Jordan also some centuries ago had a highly developed civilization marked by a prosperous agriculture and an active trade but the ruins of public buildings and public baths, elaborate houses and water systems as revealed by excavations, tell a story of decay. The desert fields, terraces in ruins, and the stragglings of former forests are all that mark the ancestral prosperity though they characterize modern poverty and decadence. This area near the Sinai region, it is believed at one time supported as many as 100,000 people; today it has probably not over 2000 Nomad Bedouins.[5]

The cradle of civilization, Mesopotamia, is characterized by the same type of decadence. The civilization was built on an elaborate system of irrigation. The irrigation ditches furnished water to the land and connected the Euphrates and the Tigris rivers. Silt has covered these ancient ditches and the irrigated lands have been allowed to revert to desert. These valleys, which once supported from 30,000,000 to 50,000,000 people with renowned civilization, refinement and learning, now maintain about 5,000,000 people living in a low state of existence.[6]

A high civilization also once flourished in North Africa. Today the stone remains of great cities are strewn over the waterless landscape like the skeletons which once marked the plains of our own country. Ruined olive presses likewise dot the countryside indicating that at one time olive groves must have been abundant. Man-made erosion has transformed a once productive area into waste.[7]

Not all decadence of civilizatilns has occurred in Asia and Africa. Our own Southwest once supported a rather highly developed people. If one visits the Chaco Canyon in Western New Mexico today he will find only here and there a Navajo. All farming has disappeared. Even grazing opportunities are gone. But he will also find from 35 to 40 ruined pueblos. Their size suggests that about 1000 A.D. there lived in this canyon some 100,000 people. What happened? Forests once grew to the edge of the canyon; these forests were destroyed and could not reseed

[4] "Erosion at Its Worst, and a Hundred Dead Cities," *Soil Conservation*, The Official Organ of the Soil Conservation Service, U. S. Department of Agriculture, December, 1939, pp. 157–158.

[5] Lowdermilk, Walter C., "The Lost Agriculture of Trans Jordan," *Soil Conservation*, March, 1940, pp. 228–229.

[6] Lowdermilk, Walter C., "The Eleventh Commandment," *American Forests*, January, 1940.

[7] Lowdermilk, Walter C., "The Eleventh Commandment," *American Forests*, January, 1940, p. 13.

themselves, thus, Nature's economy was thrown out of balance and she took a revenge by turning the land into a desert.[8]

Much of the land inhabited today in our country is in various stages of decline toward similar waste areas.

Land and Rural Welfare

The history of rural America has been one constant story of land devastation driving men from the East toward the West since the early colonial period until the last decade which has been characterized by the jalope and the Joads. The ever rapidly changing and moving American frontier which determined the course of many political rivers in our national life over a period of many decades was a partial consequence of the declining lands of the East. Frederick Jackson Turner, in a paper read at the meeting of the American Historical Association in 1893 said when speaking of the migration westward:

"Obviously the immigrant was attracted by the cheap lands of the frontier, and even the native farmer felt their influence strongly. Year by year the farmers who lived on soil whose returns were diminished by unrotated crops were offered the virgin soil of the frontier at a nominal price. Their growing families demanded more lands and these were dear. The competition of the unexhausted, cheap and easily tilled prairie lands compelled the farmer either to go west and continue the exhaustion of the soil on a new frontier, or to adopt intensive culture."[9]

By 1820 lands in Middle Georgia and Upper South Carolina were gullied and bare, and by 1825 farmers of middle North Carolina had occupied ridges previously thought to be unfit for cultivation. By 1850 large stretches of Maryland and Virginia lands previously cultivated lay exhausted and covered with underbrush.[10]

America has had a folkway of land use which was to exhaust it and leave it; its lands have been exploited through adherence to an economic folkway that regarded the land as an individual possession, with all rights resting in the owner, and a legal pattern that supported the folkway. Adherence to this folkway has permitted erosion to ruin or seriously to impoverish some 282,000,000 acres of land in this country. Then in addition, another

[8] Hawley, Florence M. and Clark, Neil M., "Trees Do Not Lie," in *American Forests*, February, 1940, p. 95.

[9] *The Frontier in American History*, Henry Holt and Co., 1937, pp. 22–23.

[10] Gray, Lewis C., *History of Southern Agriculture in the United States to 1860*, quoted by Russell Lord in *To Hold This Soil*, op. cit., p. 30.

775,000,000 acres have had their fertility seriously impaired.[11]

This maladjustment of man and land, especially the land, was succinctly manifest in the records of the families receiving unemployment relief in the early days of the Federal Emergency Relief Administration. These records show that there were six well-defined rural areas where poverty predominated over security. These regions were the Appalachian-Ozark, the Lake States Cut-Over, the Short-Grass Spring Wheat, the Short-Grass Winter Wheat, the Western Cotton and Eastern Cotton. In these regions lived more than 40% of the farmers in 1930. In the two cotton regions lived 77% of all the farm croppers in the United States. In all these regions poverty was not the immediate result of the financial depression, though the depression aggravated the situation, but the inevitable consequences of long time trends in the destruction of our natural resources, forests and soil. In the Appalachian-Ozark and the Lake States Cut-Over areas, forest have been destroyed and workers and their families left to exist on land that rapidly declined in fertility through cultivation and erosion.

The maladjustments in the Great Plains, in which are the two wheat regions, arose from the overcultivation of the land, the attempt of too many people to live off the land, and the two emergencies, the drought and the financial depression. In some of the counties within this general area, relief was extended to 70 or 80% of the farm families in 1934 and 1935, the years of intense drought.

The old South and the Southwest have become what President Roosevelt called our "Economic Problem Number One." Here the pressure of the population on the land has become especially marked. In fact, the figures indicate that in 1935 there were twice as many families trying to gain a living from the farms of the South as in 1860 and making the attempt on less land and poorer land.[12]

Generalizations become of more value to us when tied to concrete cases. Accordingly Pope County in the Ozark section of southern Illinois provides one picture. From the slopes of the county much of the loess soil has been removed, a serious prob-

[11] Bennett, Hugh H., *Soil Conservation*, New York, McGraw-Hill Book Co., 1939, p. 13.

[12] Beck, P. G., *Six Rural Problem Areas*, Federal Emergency Relief Administration, Research Monograph 1, Washington, D.C., 1935.

Kifer, R. S., *Farming Hazards in the Drought Area*, Works Progress Administration, Research Monograph XVI, Washington, D.C., 1938.

Zimmerman, Carle C. and Whetten, Nathan L., *Rural Families on Relief*, Works Progress Administration, Research Monograph XVII, Washington, D.C., 1938.

lem of erosion exists on some 100,000 acres in the county.

In years past, potatoes, corn, wheat, oats, and red clover thrived. Today red clover cannot be grown with any degree of success, potato production for commercial purposes has been abandoned, wheat production has dropped precipitously and the average yield of corn on many of the old farms is about 15 bushels per acre. In 1910 there were over 211,000 acres under cultivation; by 1935 this number of acres had declined to approximately 182,000 acres. The number of farms declined in this period from 1825 to 1476, though the average size of farms grew from 116 acres to 124 acres. In 1929 the average gross income per farm in Pope County was $820, with 45% of all the farm families having an income of less than $600. This was in marked contrast with the $2,467 average farm income for Illinois in 1929.

This eroded county reached the peak of its population, which is all rural, in 1890 when living in it were 14,016 people. By 1930, this number had declined to 7,996, a drop of 43%. There was a slight increase in the population between 1930 and 1935 owing to the general movement of population back from the cities, but this population settled on the poorest land, aggravating the already existing poverty conditions. The population was practically the same in 1940 as in 1930 which indicates that the land has inevitably continued to produce its crop of poverty since 1935.[13]

If we turn to the mountains of North Carolina we find similar conditions except that during the last few years the population has rapidly increased, adding to the burden of living on an already overpopulated soil. Avery tells a discouraging but revealing story about the situation in one of the poor mountain counties. Farm land is the county's chief source of income, though the slopes are steep and the soils are poor. That fact, however, does not prevent the movement of farms up the mountain side with an inevitable destruction of the growing timber and then the land itself. The number of farms increased from 1,410 in 1930 to 1,990 in 1935, which was more than 40%. The average size of the farm, however, fell from 62.1 acres to 47.4 acres during these same five years. But consider the consequences. Except for a few farmers who had a steer, only one-fourth had any workstock in 1935. During a field study that

[13] Fielder, V. B. and Lindstrom, D. E., "Land Use and Family Welfare in Pope County, Illinois," Department of Agricultural Economics, Research in Rural Sociology, Agricultural Experiment Station, University of Illinois, in cooperation with the Division of Land Economics, Bureau of Agricultural Economics, United States Department of Agriculture, July, 1939.

was made of the farming conditions of this county, children were occasionally seen pulling the plows, while in other cases the family cow was pressed into service.[14] While conditions such as these prevail the population continues to increase; in 1930 the number living in the county was 11,803 but by 1940 the number had increased to 13,552, a growth of 14.8%.[15]

In the cut-over areas of Michigan, Minnesota, and Wisconsin the poverty of the rural families is the result of the closing down of industry and the attempt of many families, some with a background of employment in industry, to make a living from land from which the timber, a natural resource, had been cut and which is unadapted to the agriculture that was attempted. In this case it is the misuse and waste of the natural resources and also the misuse of the land.

Misuse of land is much more widespread in the South and here it also affects many more families. The increase of eroded soils of the South has been accompanied by a receding welfare of the people. "For 25 years ending in 1935," says Dr. T. J. Woofter, Jr. "the net drift was down the ladder, with losses in ownership and independent renting and large gains in the helpless sharecropper class, fixing the institution of tenancy more firmly in the southern agricultural organization. This arrest in the expansion of the family size farm is one of the most fundamental changes in southern rural life since . . . tenancy profoundly influences the personal characteristics of the tenant, his housing and diet, his social contacts and his institutional advantages."[16]

As suggested in the quotation from Dr. Woofter, the way the land is operated and the technology used in the agricultural operations both have much to do with the general welfare of the people. In southeast Missouri the soil is moderately to highly productive, but the system of farm tenure is characterized by a very high rate of tenancy by large corporate and individual landholdings and operation by an unusually large proportion of day wage laborers. The living conditions here are among the worst in rural America. "The houses in which the white sharecroppers and farm laborers live are crude shacks. The typical dwelling in

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[14] Dodson, L. S., *Living Conditions and Population Migration in Four Appalachian Counties*, United States Dept. of Agriculture, Farm Security Administration and Bureau of Agricultural Economics Cooperating, Social Research Report No. III, Washington, D.C., October, 1937.

[15] Preliminary Population Figures, North Carolina, Bureau of the Census.

[16] *Landlord and Tenant on the Cotton Plantation*, Works Progress Administration, Research Monograph V, Washington, D.C., 1936, p. 14.

the area is a 'box' house boarded up and down with narrow stripping over the cracks to keep out the weather. Single floors with many cracks and made of rough lumber are the rule. The roof is frequently of the 'dry weather' type. Inside walls are covered with building paper, cardboard or newspaper, or are bare. The exterior is unpainted. Such are the homes of some 20,000 share croppers and laborer families."[17]

One illustration will be sufficient to tell the story of technology and human welfare on the land. In 1930 there were about 900,000 tractors on American farms, in 1938 the number was approximately 1,528,000. The displacement of tenants by the tractor is well illustrated by two plantations in the Mississippi delta. On the one plantation the management reduced the number of tenant families from 40 to 24 when tractors were introduced. At the other one 130 of the 160 cropper families were released when 22 tractors and 13 four-row cultivators were purchased.[18]

The mechanization of agriculture—a change of technology in respect to the change in the method of handling the land, is creating a migratory labor class. Today there are a million to two million farmers adrift on the land. They work in the orange groves, the celery fields, and bean fields of Florida, the truck farms of the Atlantic states farther up the coast, in the cotton fields of the Southwest, in the sugar beet fields of Michigan, Colorado, and Montana, they seek homes in California. They are a people without resources, with no fixed homes and are frequently denied their civil liberties in this land of freedom. This, indeed, is in sharp contrast to the development of democracy which found its fruition on the land beginning in New England and spreading to the shores of California.

Land and Urban Welfare

Thus far the discussion has been directed into the general consideration of the relation of the land to civilization itself, taken over a long period of time, and of land in rural territory to the people who are directly concerned with making a living on it. We now turn to another field, of equal significance, if not of greater significance, to the welfare of the nation. It is the relation of the city to the land.

[17] White, Max R., Ensminger, Douglas and Gregory, Cecil L., *Rich Land-Poor People*, United States Dept. of Agriculture, Farm Security Administration, Region III, Research Report No. 1, Indianapolis, January, 1938.

[18] Coverley, H. M., *The Dilemma of the Land Hungry*, Land Policy Review, Bureau of Agricultural Economics, United States Dept. of Agriculture, September, 1940, p. 20.

Cities hold a direct spatial relation to the land upon which they are built, and a direct economic relation to the hinterland from which they draw their men, women and raw resources. With respect to the first of these, the relation of the population of a city to the land on which the city is built, Henry George made the following poignant statement many years ago: "Wherever you find land relatively low will you not find wages relatively high? And wherever land is high will you not find wages low? As land increases in value, poverty deepens and pauperism appears."[19]

The accuracy of this generalization can undoubtedly be proved by recourse to the history of most any city in the United States. The land values of the cities have risen by reason of the fact that there has been, until within the last decade, a constant pressure of population on land in the cities due to the migration from the country. But within the last decade land values have been declining in our cities, the speed and force of the population flow from the farms have diminished in intensity. While this was happening blights have spread within the cities, land values have declined, taxes have gone unpaid, and the population has spread to the fringes by the hundreds of thousands. At this point I wish to throw out a question. Is there a causal relation or is it only a coincidence that the cities have shown all these symptoms of decline at about the same time that the wholesale effects of eroded soils began to make themselves felt in rural territory? Undoubtedly the cities have been built by reason of the fact that the products of the soils were sent to the cities, the soils were left to erode.

The cost of building our cities has seldom been counted, these gargantuan concentrations of population have been looked upon as capstones of civilization, we have been taught to believe that the cities represent the zenith of civilization's efficiency. But in them are found the nadir of civilization as well. Perhaps Henry George was correct in insisting that many of the maladjustments in the cities such as slums, poor housing, crime, poor health, etc., are a direct result of the wrong relation to the land. After all the cities have grown through the exploitation of land values; land in the city is considered only a commodity to be manipulated for profit. Carol Aronovici has well summarized this position. To quote: "We have attempted to reap the benefits from a growing population and a mounting national wealth in the

[19] *Progress and Poverty*, Modern Library Edition, p. 288.

exploitation of land as space for urban living . . .

"The transition which urban land has undergone from pioneer days to its present exploitational phase, and the eventual social and economic obsolescence of large areas of our cities, has resulted in the creation of blight and slums, which have involved both the welfare of our communities and the security of investment in real property."[20]

The misuse of the land has done much to create the blight and slums. One of the worst misuses is overcrowding for the sake of profit. A report of the Regional Planning Committee of Harrisburg, Pennsylvania in describing the situation in that city illustrates a common condition. The report says, "The areas in metropolitan Harrisburg in which occur the worst residential crowding are, generally speaking, lacking in neighborhood parks and playgrounds. . . . To make conditions worse, many streets in the central city which are of no more than alley width, and which in many instances were intended to serve only as alleys have had residences built on them with continuance frontage . . . The future of such dwellings cannot avoid a downward trend . . . There has never been any valid reason for the narrow lots that characterize Harrisburg and its older suburbs."

The cities are beginning to pay for the misuse of their land since the automobile gives people a chance to migrate to the fringes, while property values decline. "In one downtown business district a recent study revealed that its aggregate market value, estimated on the basis of sales, had decreased from $156,200,000 in 1914 to $61,600,000 in 1939. During this same period the aggregate assessed valuation of property in this district had decreased from $136,496,000 to $97,757,800."[21] The capital loss which many of our cities have experienced during the last few years, occasioned by community disintegration is apparent to the casual observer. Moreover the shrinkage in investment values does not represent all the loss. For example, in a Cleveland blighted district the municipal income per year was $225,000, but the cost of maintaining the area was $1,900,000. A square mile in Chicago, during a recent three year period, returned $586,000 in taxes, while the city's outlay for public services was $3,200,000.[22]

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[20] *Housing the Masses*, New York, John Wiley and Sons, Inc., 1939, p. 3.

[21] *Improvement of Housing in Cities*, Committee Report, United States Chamber of Commerce, Washington, D.C., 1940, p. 12.

[22] *Waverley: A Demonstration of Neighborhood Conservation*, Federal Home Loan Bank Review, June, 1940, pp. 290–293.

Much of this loss is due to the misuse of land like that of New York's lower East Side. This area should be the most desirable place for living but it is not. The historic elements that have played a part in its development have, according to Aronovici, destroyed a "good share of the values inherent in its geographical location."[23]

These faults of our cities might be excused on the grounds of ignorance and the American spirit of enterprise were it not for the fact that we are continuing the misuse of land at an accellerated rate. Population is leaving the cities and settling in the fringes. As the fringes are built up all the mistakes that were made in the cities over many generations are being repeated in the fringes. Many believe that we are creating slums in the areas about the cities faster than we are clearing them from within the cities. Many of the stories which I hear lead me to believe that the observation is accurate. We are misusing the land in the development of the metropolitan areas as we have misused the land in the evolution of the congested parts of the cities.

Conclusion

The danger of misuse of the land does not lie alone in the way the farmer handles his soil, but also in the wrong disposition of city real estate. Moreover, as long as the cities can exploit the rural dweller, just so long will the farmer abuse his soil. The saving of the soil, the proper use of the land in country, city and fringe may be the largest single factor in determining the economic welfare, even democracy itself, in America. Without the proper relation of man to land I feel the astute thinker may well ask, "What are we in America striving to defend?"

[23] Op. cit., p. 6.

NEW DISEASE OF CARNATIONS

Carnations are being killed by a new disease, caused by an apparently unknown bacterium. The malady made its first appearance in a greenhouse at Spokane and is reported by Leon K. Jones of the State College of Washington.

Characteristic of the new malady is the production of grayish-green foliage, followed by yellowing and death of the plants, similar to the symptoms commonly associated with the wilt disease. Yellow streaks of frayed tissue in the woody areas, extending 12 to 24 inches up the stems of affected plants, are distinguishing symptoms. The disease is most damaging during warm weather of fall and spring.

W. H. Burkholder, plant pathologist of Cornell University, at Ithaca, New York, is studying the bacterium to determine its exact identity.

NEW DEVELOPMENTS IN PHOTOGRAPHY

CHARLES A. SAVAGE
Instructor in Photography
Rochester Athenaeum and Mechanics Institute

[EDITOR'S NOTE. Mr. Savage's career as a research specialist and teacher began with a school-boy interest in photography. He began with a small dark room in the basement of his home in Warren, Pennsylvania. His success soon attracted public attention. This resulted in many appointments in his home studio. He attended the Rochester Athenaeum and Mechanics Institute and later became a member of the faculty. In his article he briefly describes some of the recent developments in photography that will be of interest to science teachers in schools an colleges. D.W.R.]

There have been three outstanding fields of development during the past year and each has broadened the scope of photographic science to a marked degree. The first deals with lighting and equipment such as the *Kodatron Speedlamp*, the *midget-type flashbulb*, and the use of fluorescent lights. Second, in the field of projection equipment is noted the development of greater precision in American-made cameras, enlargers to compensate for distorted perspective, and *Varigam* variable contrast printing paper. The third area of development has been the continual increase of courses in photographic science in schools and colleges.

I. LIGHTING EQUIPMENT

1. The Kodatron speedlamp. The new speedlamp is probably one of the most important developments of the year. Although for several years it has been possible to make ultra-high speed photographic exposures, such equipment was available to only a very few persons. The new lamp was designed by Prof. H. E. Edgerton of the Massachusetts Institute of Technology and is now being distributed by the Eastman Kodak Company. The lamp produces an effective light flash with a duration of only 1/30,000 second! It has opened new possibilities to schools and colleges to conduct low cost experiments of this kind in the classrooms. It is a sensation to think of the developments that may grow out of the many stop-action studies of both human and mechanical motion when production allows this device to become widely used. In every field of science and industry this light will make high speed analysis a commonplace procedure. Also, it is obvious that such fast exposures will simplify many

old photographic problems of the illustrators and portrait artists. Taking pictures of highly animated children, dancers, or animals, in fact, pictures of any fast action has always been a major difficulty. Much of the regular commercial photographers everyday work will consist of making defect analysis pictures of fast moving machinery and will result in new income.

The light operates on the regular 110 volt 60 cycle line. It is quite portable and convenient to use. The complete unit consists of the Kodatron tube and a removable reflector mounted on an extension standard which, in turn, is fastened to a sturdy castor base. The base, also, acts as a carrier for the power supply unit. The tube and power unit can be detached from the base for field use. It is interesting to know that the flash is accomplished by a gaseous discharge. The Kodatron tube contains Krypton and Xenon. About 2000 volts for the discharge is stored in condensers which are capable of building up the necessary power in about 10 seconds. The Kodatron tube is replaceable and has a life of about 5000 flashes. Mounted within the tube is a secondary light used for focusing and to accurately indicate the lighting that will result from the flash. This feature is an example of the practical design of the entire machine.

2. *The "midget" flashbulbs.* These lamps are about the size of an automobile headlight bulb and, similarly, have a bayonet type base. Obviously these two features add to the convenience of using flash equipment. It is possible to carry thirty of these bulbs in an ordinary coat pocket that would hold only two or three large bulbs. The positive contact and simple mechanism of the bayonet base and socket help to reduce the probability of failure. Even more important, the light source is small enough to allow efficient concentration of light by parabolic reflector. The old style large bulbs only permit flood-light illumination close to the camera. Reflectors for the small bulbs will direct sufficient light for exposure to objects as far as 150 feet from the camera.

Adjustable-focus reflectors have been designed for the inexpensive "midget" bulbs. Such equipment provides either a close-flood or a distant spot of illumination. Obviously, this opens up new possibilities in flash-photography, such as sports and news. Those who wish to photograph wild life at night will find the problems very much simplified by the carrying power of this directed-flash. The use of a telephoto lens with flash becomes quite practical.

3. The fluorescent light. This light answers the photographers' wish for a cold light which has high actinic value. Too much heat is produced by the ordinary incandescent lamp of high intensity. In portraiture, for example, it is often quite uncomfortable for the subject to pose for any length of time under hot lights. Being cool, fluorescent lights fulfill this and other needs. They can be conveniently used for projection work where there is danger of buckling or actually burning film with ordinary bulbs. Although it is difficult to obtain a great intensity with the present fluorescent tubes, the actinic value, or exposing power of the light, is very high.

The tubular shape of these lights is another advantage. It makes it possible to place several units side by side in a reflector to form a broad source of light that will cast no sharp shadows on or from the subject. Incidentally, this softness, together with a pleasant color, eliminates the eye strain usual to the use of ordinary lights. With regular bulbs such a soft, broad light source can only be obtained by the use of a diffusion screen between the subject and light. Diffusion causes loss of intensity and economy.

The actual color of fluorescent light is very close to that of daylight. This is an advantage in photography since most films are more sensitive to daylight than to tungsten light. All these factors point to the efficiency of fluorescent light, plus the fact that its power consumption is lower than ordinary light of equal effectiveness.

II. Projection Equipment

Developments in camera and projection equipment have not been as revolutionary as those in the field of lighting. Progress has been made, however, through constant improvement in engineering and production. Thus, finer quality and more features are available at lower cost. Difficulty with foreign importation has given American manufacturers the necessary incentive to build cameras of instrument precision equal to the famous imported types.

1. Enlargers. There has been very definite improvement in the design of enlargers. This is particularly true of enlargers built for small-size negatives. Many new projection machines are constructed so that the plane of the easel and that of the negative carrier can be adjusted to compensate for distorted perspective in the negative image. Further, on some machines the plane of the axis of the lens can be changed to facilitate focusing

the image when the easel and carrier are not used in their normal, parallel positions. These adjustments are very valuable to the photographer whose camera has no swing back feature. To explain, very few hand cameras have enough, if any, rising front or swing back adjustments to allow the user to photograph a subject such as a tall building without pointing the camera upward. This means that the plane of the film cannot be verticle and parallel to the building. The resulting image will make the building appear too narrow at the top. The picture will have exaggerated perspective since we don't think of buildings as having tapered sides. A negative of this description can be printed without difficulty in the new enlargers so that the building will appear normal. Thus a long felt projection equipment need has been taken care of by application of the same principles that have been used on view cameras for years.

2. Varigam. The latest and most outstanding achievement in the progress made with sensitized materials is the introduction of variable contrast enlarging paper. It is known as "*Varigam.*" Ordinary photographic papers are usually made in several grades of contrast to compensate for the difference in density range or contrast often found in negatives made under various lighting conditions. This new paper, however, is made with controllable contrast which not only eliminates the necessity for stocking various papers but introduces a new technique for special effects and correction.

Contrast control is made possible by the fact that the paper has very soft gradation when an exposure is made through a yellow filter and very high contrast when exposed through a blue filter. Combined use of the filters permits any intermediate degree of contrast to be obtained. What might be termed "normal" contrast results when about equal exposure time is given through each filter. Very interesting effects can be obtained by "dodging" through these filters, that is, by manipulating the filters. Thus any part of an image can be given more or less contrast as desired by the operator.

3. Pola-screens. The use of these screens over the light source was introduced several years ago but only recently has this usage become popular. Consequently, it is appropriate that they be mentioned here. Pola-screens for use over the camera lens, of course, have been available for several years. When used alone their effectiveness is somewhat limited—under certain conditions. However, almost perfect control of reflected light is pos-

sible through the combined use of light screens and lens screens when artificial illumination can be used. All science as well as photography itself is benefited by the availability of this equipment. One of the most interesting uses of polarizing equipment is that of making photographic copies of oil paintings. The rough yet glossy surface of an oil painting reflects many highlights and, consequently, when photographed by ordinary methods each brush mark is exaggerated in the finished print. When photographed with the aid of pola-screens the reflection of the surface texture of a painting can be completely eliminated and the result is a true rendition of the actual tone variations beneath the glossy surface of the painting. This technique applied to three-color photography makes possible inexpensive reproductions of excellent quality and will permit art lovers to study copies of their favorite paintings with much more satisfaction.

To understand the use of pola-screens we must first remember that the detail in the image of a painting is formed by light that is *diffusely* reflected from beneath the glossy surface, whereas the "highlights" on the ridges of the brush marks are due to *specular* reflection. Therefore, if the specular reflection is eliminated from the image of the painting the "highlights" of the brush marks disappear. To do this, the incident rays are polarized by a pola-screen at the source, then, since specular reflection does not depolarize the light, the reflected rays are completely stopped before they reach the lens by a second pola-screen before the lens set with its axis of polarization perpendicular to the direction of vibration in the polarized rays. Thus, with specular reflection and its "highlights" eliminated, the light which actually forms the image in the camera is that which has been depolarized by diffuse reflection and, consequently, is able to pass the pola-screen at the lens.

III. Photography in Schools and Colleges

The mechanical devices designed to improve the technique and quality of photography are undoubtedly worthwhile and interesting. However, we must not overlook the other aspects of progress in photography. A very important development directly concerns teachers. Plans are being made by many schools and colleges to expand photographic educational programs. This has come about since the public has been made to realize that photography is no longer simply a trade but has its foundation in science and art. Publicity of this fact is largely due

to widespread advanced amateur interest and popular reading. Professional photography in all fields has gained very real prestige. It is well deserved since photography in various forms constitutes one of the nations major industries. Facilities for academic education in this field are in demand and truly needed. Only recently, have any educational institutions offered more than a semester or two of photography, usually as an elective. However, progress is being made.

The industrial arts schools have pioneered this work for the past decade. The Rochester Athenaeum and Mechanics Institute in Rochester, New York, offers three-year courses in both Photographic Technology and Professional Photography. The demand for these courses is such that the school is forced to turn away many applicants each year.

The expansion of education in photography means a growing demand for teachers who know photography, or, perhaps, photographers who know education.

CHEMISTRY IN GENERAL EDUCATION

R. J. HOLDER
Lorain High School, Lorain, Ohio

Probably everyone will agree that a pupil has not received what could be called a general education unless he has some appreciation for and knowledge of the physical sciences. One of the often mentioned outcomes of a science course is an appreciation for what science and technology has done for progress. Too often we are satisfied with that variety of appreciation which is nothing more than open-mouthed awe, which reminds one of that expression, "Ain't nature wonderful." Such appreciation for science the student has *before* the 11th or 12th grades. You have often heard the chemically ignorant remark about a visibly reacting substance that, "It must be an acid."

To secure a more intelligent appreciation the pupil must learn to use scientific facts and observations to reach a conclusion. Chemistry will have to be taught in such a manner that pupils can be trained in the use of the scientific method. We teachers need to do a great deal of experimenting in the classroom and laboratory in order to learn the technique of teaching pupils the use of the scientific method, and how it can function in the solution of modern problems.

There are those who would discredit chemistry because it lacks utilitarian values. Does everything we teach have to point in that direction? Let me ask the question, Are social sciences the practical thing their publicizing agents would have us believe? Does it follow, that if a pupil takes three required social science courses, he will vote that much more intelligently? We chemistry teachers have long felt that we can justify the teaching of our subject in a democracy, too. We can develop desirable social attitudes, also. However, our teaching must be revised to deliberately achieve these attitudes, rather than to claim them as concomitant outcomes.

Dean Wittke of Oberlin College, a former professor of history at Ohio State University, speaking before a group of teachers stated that we needed not only courses which contribute to a worthier use of leisure time, but also some science courses which develop a respect for facts, and that science will probably be an important part of tomorrow's culture. A worthy tribute from a social science man.

Modern education theory would have us modernize, humanize and socialize the individual. A beautiful thought and worthy of achievement. But it seems absurd to attempt to do so without some factual knowledge. Most of our high school subjects have been so softened that our pupils suffer from mental pyorrhea. Let us keep chemistry one of those subjects that requires concentration, accurate statements, a vast respect for truth and opinions based on facts and observations rather than merely opining by right of free speech.

By its very nature, chemistry is a complex subject. Its vocabulary is large and new to the student. We could make it a more teachable subject by eliminating the number of words new to the student, e.g. deoxidation for reduction, metallic oxide for basic anhydride, etc. The subject matter is different from any subject preceding it in the curriculum.

We probably try to teach too much to high school pupils in a year of chemistry. The day of homework seems to be passing away, yet many still try to teach as much subject matter as formerly. Youngsters like to do what they are capable of doing. If we assign more work than they can do, they lose interest, and, therefore, the quality of their work becomes poorer.

Are difficult subjects wanted? Do parents want their children to take difficult subjects? What sells the educational program to the public? Is it our classroom work? If not, and if the public

wants a less difficult curriculum, we will have to require less, but let's keep it scientific, and I do not mean general science. Chemistry can't be such an undesirable subject, because about ¼ of the college students who had studied chemistry in high schools took at least a year of chemistry while in college.

Some studies now seem to indicate that transfer of training does operate. If so, I use that finding as an argument for the teaching of chemistry. The thinking process, generalizing, deducing, theorizing, testing, and expressing thoughts quantitatively are possible outcomes of a chemistry course. Certainly, clear-thinking is a need of democracy.

The readers of modern periodicals need some protection from popular scientific literature. One study shows that students of chemistry are able to make a more intelligent interpretation of such literature than people who have not studied chemistry. Since it now appears that chemurgy may be the solution for the oversupply in agriculture, it is only fitting that chemistry be not forgotten in building a curriculum.

The interpretation and use of good English is stimulated in a chemistry course. Following directions in an experiment, giving directions for performing an experiment, and describing results all require good English. Mathematics and physics are probably the only other subject matter fields that require this degree of accuracy in the use of English.

A SIMPLE MAGNETIZING DEVICE

CLARK LAY, *Central Union High, El Centro, Calif.*

Several devices for magnetizing bar magnets have appeared in the columns of SCHOOL SCIENCE AND MATHEMATICS, but none, I believe, as simple or efficient as the following which any science student can construct in a few minutes.

Wind about 100 turns of No. 18 double-cotton-covered copper wire on a tube 1 to 2 inches in diameter. Slip off this coil and dip in paraffin to hold in shape. Mount on a board of convenient size. Next mount on the board a fuse holder. (A couple of "bobby pins" an inch apart is excellent or two fahenstock clips). Connect the coil and fuse in series and to an extension cord.

In operation place the object to be magnetized lengthwise inside the coil, put in a fuse of tinfoil not over one-quarter inch in width, plug into a 110-volt circuit and the job is done! The resistance of the coil is so small that a large current flows and burns out the fuse. You will find it works amazingly well. Cobalt alloy magnets whose strength had abated have been restored to an even better condition than that in which they were received from the manufacturer.

A NOTE ON THE ROTATION OF AXES

RALPH MANSFIELD
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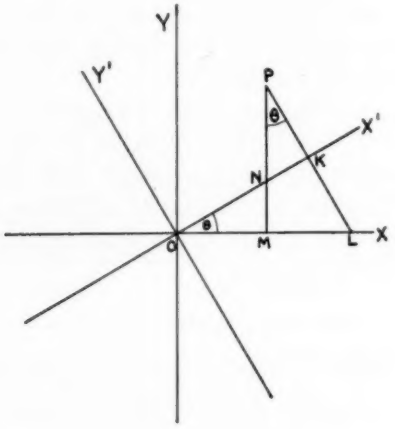
In the figure below, let the X, Y, X', Y' axes be denoted by OX, OY, OX', OY' respectively, where it is to be understood that we are working with rectangular coordinate systems. The point P then has coordinates (x, y) and (x', y') in the two systems. Let angle XOX' = angle $YOY' = \theta$. Let the foot of the perpendicular from P to OX be denoted by M, and let the perpendicular intersect the X' axis in N. Let the foot of the perpendicular from P to OX' be denoted by K, and let this perpendicular intersect the X axis in L. Now, obviously, angle $MPL = \theta$, $OM = x$, $PM = y$, $OK = x'$, $PK = y'$.



From the figure,

$$x = (x' - NK) \cos \theta,$$

but,

$$NK = y' \tan \theta,$$

therefore,

(1) $$x = x' \cos \theta - y' \sin \theta.$$

Also,

$$y = (y' + KL) \cos \theta,$$

but,

$$KL = x' \tan \theta,$$

therefore,

(2) $$y = x' \sin + y' \cos \theta.$$

Furthermore,

$$x' = (x + ML) \cos \theta,$$

but,

$$ML = y \tan \theta,$$

therefore,

$$x' = x \cos \theta + y \sin \theta. \tag{3}$$

Again,

$$y' = (y - NM) \cos \theta,$$

but,

$$NM = x \tan \theta,$$

therefore,

$$y' = -x \sin \theta + y \cos \theta. \tag{4}$$

If θ is greater than 90° but less than 180° and a point P_1 is taken in the second quadrant to lie between the axes Y and X', then the preceding demonstration is readily seen to hold with the angle $MP_1L = 180° - \theta$. Also, if θ is greater than 180° and less than 270° and a point P_2 is taken in the third quadrant to lie between the axes X' and the negative part of Y, the demonstration is again seen to hold with angle $MP_2L = 270° - \theta$. Likewise, the demonstration holds in the fourth quadrant.

Now, in case the point P is taken to lie between X and X' in the first quadrant, the demonstration still holds since $KN = -NK$ and $KP = -PK$. With this in mind, in view of the above paragraph, the demonstration is also seen to be valid in the remaining quadrants.

NEW GOVERNMENT AIDS FOR TEACHERS

"New Government Aids for Teachers" is the title of a 24-page publication just issued by the U. S. Office of Education.

Announcements of Government aids for teachers appear each month in *School Life*, official journal of the U. S. Office of Education. The new publication reprints a series of these regularly featured *School Life* announcements.

Included in the annotated listings prepared by Margaret F. Ryan, editorial assistant, are free and low cost books, pamphlets, charts, maps, exhibits, films, slides, and other Government-prepared materials available to teachers and school officials.

Selected aids on more than 500 subjects appear in the list which represents a cross section of the many types of publications and materials available to schools from Federal Government agencies.

The bulletin also includes a list of current publications of the U. S. Office of Education, good reference bibliographies, publications of the President's Advisory Committee on Education, and price lists of Government publications on 46 subjects.

METHODS USED IN SECURING PHYSICAL SCIENCE MATERIALS AT SMALL COST

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Hamtramck High School, Hamtramck, Michigan

A major problem in the teaching of general science and physics is the obtaining of supplies and equipment. Even in those fortunate schools where the budget restrictions are not severe. there tends to be a discouraging lag between the realization of the need for materials and their subsequent delivery. Faced in Hamtramck High School with a shortage of supplies and equipment, techniques for obtaining materials at little or no cost from the surrounding community were used.

The first step was the obtaining of a number of old radio sets and parts of sets from the radio stores. These radios had been turned in on the purchase of new ones, and many of them were to be disposed of for junk. The dealers were glad to give them to the school. These business men, in common with others in the city, had an interest in the school strong enough to make them willing to give items of this type to the school. Radio sets and parts were obtained in such excess that they became valuable both as additions to the department, and as stock in trade for use in giving to students in exchange for other materials needed. Some of the more able students repaired a number of the sets. These were then traded for a large collection of old tools, nuts, bolts, screws, and other basic materials needed around the laboratory in building and adapting equipment. A surprisingly varied collection of other things, such as old horn motors, automobile ammeters, thermostats, switches, and electrical toys was also brought in. Some of these came as the result of trades, others came as gifts from the students.

The radio sets furnished all necessary materials for those students interested in working with vacuum tube or crystal sets. The radio sets furnished materials which could be used in a variety of ways. Obtained from them were:

Copper wire, in large quantities, and in many sizes
Copper and aluminum shields, valuable for beakers
Copper, aluminum, and iron for raw materials
Condensers, both fixed and variable
Resistances, both fixed and variable
Coils, in large quantities, and in many varieties
Permanent magnets and electromagnets from loud speakers

Dry plate rectifiers from loud speakers, suitable for use in building battery chargers
Transformers in great variety, suitable for use both as they were and as basic materials for building special transformers
Vacuum tubes, useful in a number of experiments
B-Battery eliminators
Miscellaneous nuts, bolts, connections, wire, and other parts

There being no source of direct current available, an out of the pocket expenditure for some automobile storage batteries was made. These batteries, taken from junked automobiles, were in fairly good condition. As they were bought at a junk price, and will be sold again for junk, little personal expense is involved.

In order to keep the batteries charged, it was necessary to build a battery charger. It would have been possible to build a rectifier type charger, using a radio transformer and a dry plate rectifier from an old loud speaker, but it was felt that a faster charging rate than that obtainable from a dry plate rectifier was desirable. Consequently, a motor generator set was built. A household appliance store donated an old washing machine motor; a junk yard donated an automobile ammeter, and sold an automobile generator for thirty-five cents; a student assembled the motor generator set, coupling the motor and the generator with a short piece of very thick rubber hose. The set charges fifteen amperes at six volts without overloading the motor.

It should be remarked that junk dealers can not be classified with other business men when soliciting materials for the school. Their stock in trade consists of the materials which others discard, and so they can not be expected to be generous with old materials. It should also be remembered that junk has at least two prices, a high price to the person who uses it for the purpose for which it was originally designed, and a low price to the purchaser interested only in the metal itself. The purchaser should be shrewd enough to classify himself in a cheap bracket. A generator should be bought for the wire in it, in which case it will be likely to be sold at a reasonable figure. Most old generators are good. It is customary for the junk dealer to sell to the used parts trade as many of the old generators as he can; the remainder he must sell at a price based on the value of the metals. If the bearings and commutator seem good, and a look inside shows the wire on the armature to be free from char, the

machine is probably good. Incidentally, an automobile generator commands the respect and interest of students. It works well both as an experimental and as a demonstration piece of apparatus, operating as a series or shunt motor on six volts, and as a generator at six volts or slightly higher. The third brush is confusing, and may be removed for simplicity. As a demonstration of the motor and generator principles, the armature may be removed and rested in a vertical position on the base plate. There it will rotate freely. Permanent magnets may be used successfully for the field, and ordinary bare copper wire may be used as the brushes. In this position several experiments may be performed, with the essential parts clearly visible.

Another old washing machine motor furnished the power for an electric grinder. Old motors, well worth repairing, may often be bought for their value as junk. Perhaps the most frequent cause of their being junked is their having worn out bushings. New bushings may be purchased quite cheaply. The grinder motor, donated by a washing machine dealer, suffered from a different defect, an amateur electrician having broken some of the inside wiring. A student found great pleasure in finding and repairing the damage. The school machine shop furnished an arbor for carrying the grinding wheel, the wheel being the discarded middle section of a larger wheel which had been worn down to its side washers.

Automobile junk yards served as the source of a number of things obtained at little or no cost, including generators, batteries, permanent magnets, ammeters, speedometers, pressure gages, horn motors, induction coils, switches, and miscellaneous nuts, bolts, screws, and other parts. Permanent magnets from a model T Ford were obtained very cheaply, and served their prupose well. The automobile ammeter has many advantages for student use. Due to its construction, it can stand a tremendous over current without harm. It will stand considerable mechanical abuse. If stolen, not much is lost. It can be given a permanent mount, and can be calibrated in series with an expensive instrument. Speedometers aroused considerable interest in the study of gear ratios, and in the study of the worm drive. Automobile horn motors were found to be superior for student use in studying motors and generators. Their advantages lie in their ruggedness, and in the visibility of all of the parts. Induction coils without breakers were found in abundance. However, the model T type, with breaker, is becoming scarce. A headlight

dimmer switch was found by the photography club to make a superior foot switch.

While speaking of automobile parts, it may also be mentioned that an inner tube can be used as the basis of a rather startling demonstration of Pascal's law and the hydraulic press. The valve is removed, and a three or four foot piece of rubber tubing is connected on the valve stem. The inner tube is filled with water and is placed on the floor. A piece of glass tubing is connected to the rubber tubing. Then a table is placed top down on the inner tube and a heavy student steps on the table, the idea being to see how strong a fountain he can cause to play on the ceiling. To the great disappointment of the class, the water will rise only six inches or so in the glass tube. The same equipment may be used to perform the famous bursting flask experiment.

The need of a high voltage transformer led to the discovery that neon sign transformers are frequently replaced because of poor operation. They may be obtained as gifts from the places of business where the signs are located, or from the firm which services the signs. Transformers delivering five thousand and fifteen thousand volts were obtained. They performed satisfactorily. In addition the electric sign firm donated various types of discharge tubes from replaced signs.

Old electric irons and toasters were obtained by gift from the electric light company. They had been turned in on the purchase of new ones. The company had no use for them. They have been used as protective resistances in alternating current experiments, to take apart to see how they were made, and in experiments on heat, power, and resistances.

A supply of several hundred assorted lenses was obtained by gift from an oculist. They had been turned in when new lenses were purchased. Included were lenses with corrections for astigmatism, near and far sightedness, tinted lenses, and lenses with prismatic correction. Also included were lenses with various combinations of corrections. The focal lengths of some of those with simple positive and negative corrections were as little as one and two inches. It was found possible for the students to set up simple telescopes and microscopes, in addition to studying the correction of eye defects.

It should be remarked in conclusion that the techniques mentioned here constitute only a small part of those which may be used by a physical science teacher in obtaining materials. The success obtained by any teacher in using like methods will be

determined by the thoroughness with which he has ascertained his own needs, and by the persistence and ingenuity with which he investigates his surroundings for possible help in satisfying those needs. It should also be remarked that there are certain rewards which come with such activity, and help to pay for the extra time expended. In addition to the satisfactions accruing from the use of more and better materials, the teacher will have the appreciation of the local community for his efforts. More important, the teacher is likely to find that student participation in departmental building has resulted in the breaking down of barriers, and the development of interests in and a sense of ownership of the department.

A SHORT TEST FOR GEOMETRY TEACHERS

(Time: 15 minutes)

JOHN P. HOYT, *Cornwall-on-Hudson, N. Y.*

1. ABC is a triangle in which $AB=5$, $BC=6$, $CA=8$. F lies on AB and $BF=1$. H lies on AC and FH passes through the centroid of the triangle. Find CH.

2. $ACEG$ is a quadrilateral circumscribed about a circle and tangent to the circle at the points B, D, F, and H; B lying on AC, D on CE, F on EG, and H on GA. $AB=4$, $CD=6$, $EF=7$, $GH=8$. Find the radius of the circle.

3. $ABCD$ is a trapezoid and a line through the intersection of the diagonals parallel to the bases divides the legs in the ratio of 2/3 reading from smaller base to larger. Find the ratio of the bases, AD and BC.

4. Triangle ABC has angle ABC equal to 60 degrees, AB equals 7 and BC equals 8. The line through the orthocenter and the circumcenter of the triangle meets (when produced) AB at X and BC at Y. Find XY.

5. Triangle ABC has $AB=5$, $BC=7$, and $AC=8$. D lies on AB and $AD=2$. E lies on AC and AE equals 3. F lies on BC and AF passes through H the intersection of CD and BE. Find AH/HF.

6. Trapezoids $ABCD$ and $EFGH$ have their corresponding angles equal respectively. The bases of $ABCD$ are of lengths 43 and 57. The bases of $EFGH$ are of lengths 15 and 29. Find the ratio of the area of $ABCD$ to $EFGH$.

7. Triangle ABC has $AB=5$, $BC=7$, $AC=8$. D lies on AB and $AD=2$. E lies on AC and EC equals 3. DE is drawn and produced to meet BC produced at F. Find CF.

8. Triangle ABC has $AB=5$, $BC=9$, $AC=7$. D lies on AB and E on AC and DE is parallel to BC and equal to the sum of BD and EC. Find the ratio of triangle ADE to triangle ABC.

9. $ABCDE$ is a regular pentagon. AC, BD, CE, DA, and EB are drawn thus forming a regular pentagon. Find the ratio of this pentagon to $ABCDE$.

10. $ABCD$ is a quadrilateral with angles ABC and ADC right angles with $AD=5$, $BC=10$ and $AC=20$. Find BD.

STUDENT INTEREST IN SCIENCE

HERBERT S. ZIM
Ethical Culture Schools, New York, New York

Teachers of science, in common with other teachers, have long been aware that their educational task was easier when pupils were interested. Whether their goal was factual learning or more functional science, they knew that pupils would go further once interest had been achieved. Hence much attention has been given to techniques of interesting pupils in science. Studies of science interest have also been made from an entirely different angle. These have attempted to find out the interests of students and often to distinguish "real" interest from some other kind. They have been concerned with permanence of interests and differences between the interests of boys and girls. The assumption underlying these studies seems to have been that if interests were "real" and "permanent" to teach those topics in which interest was expressed; if not, to eliminate any consideration of interest in building science curricula.

The success in applying both these points of view to curriculum development has been limited because research data have been insufficient and application of the data has been superficial. Only recently the consideration of science education in the *total* development of the individual has provided a more fundamental way to consider the interests of students. This viewpoint is embodied in the report of the Committee on the Function of Science in Secondary Education.[1] The findings of this report suggest the need for reexamining the science interests of students. It suggests the development of a program of science which may meet the needs of the individuals and which may promote his fullest social participation. This implies a study of the typical interests of students in science and the needs expressed through these interests. In this way, attention is focused not only on the topic, which interested the student, but upon the significance and use of the interest to the student.

At the time this viewpoint was being developed, a research program was set up involving five schools in New York and vicinity. It was also possible to secure data from a broader, specially selected, school population. Over 7,000 research contacts were made with about 3,200 students. These pupils were

[1] Committee on the Function of Science in General Education, *Science in General Education*, D. Appleton-Century Co., New York, 1938.

equally distributed between public and private schools. They were all in junior and senior high school; the majority in grades 7 through 10. Several different techniques were used in gathering the data on science interests. These were:

1. A questionnaire of 65 questions concerning interests, activities preferences, extra-curricular activities, reading, etc., filled out by 827 pupils of grades 7 through 10. Data were obtained on subject preferences, club memberships, attitudes, museum visits, magazines read, voluntary science activities, etc.
2. Compositions on "The Thing I Would Like to Do Best in Science" were written by 1,161 pupils in English classes from two to five weeks after they had filled out the questionnaire. These freer responses were analyzed and gave data on areas of science preferred and activities desired.
3. Nine carefully prepared science exhibits were shown to 1,432 pupils in grades 7 through 10. These exhibits represented distinct areas of science. They were shown to pupils in a controlled situation, where the time spent by pupils looking at each exhibit was recorded. Pupils' votes on the most interesting and least interesting exhibits were taken and it was also possible to secure written and oral questions pertaining to the exhibits. These data gave a specific picture of adolescent preferences in the areas of science illustrated.
4. 1,114 pupils filled out a check list showing their preferences for certain scientific movie films. These fictitious films were titled and described so that they were related to the science exhibits just mentioned. These films were also used to discover scientific preferences in terms of the factors of *use*, *understanding* and *manipulation*.
5. A series of 107 questions was prepared representing a wide range of scientific information. Pupils were asked to indicate the extent they had wondered about each of the questions. They also had opportunity to write questions or topics about which they had wondered. These data on scientific wondering (891 cases) made clear the relationship between thought, fantasy, and definite science activities of young adolescents.
6. The Science Fairs of the American Institute were studied and an analysis was made of the individual exhibits, submitted by 1,576 adolescents over a period of seven years. The direct study of this voluntary science activity gave information on a group of adolescents who were "interested in science." Comparisons were made between the typical interests of this group and the unselected adolescents in the schools.

In addition to these six techniques, another phase of the research was concerned with students who were "interested" in science. The criteria of interest used were voluntary participation in science activities. Many adolescents, interested in science, submit exhibits to the Science and Engineering Fairs of the American Institute, held annually in New York. For two years the individuals, submitting exhibits, were studied. Quesionnaires were filled out by 191 boys and 39 girls. Further data were obtained from autobiographies and from correspondence with exhibitors. In one of the cooperating schools, a group of interested pupils was observed for a two to five year period. Case histories of these students were kept, which included many

data on their science activities in and out of school, their academic and social growth, physical development, etc. These data gave indication of the relationship between a science interest and the development of personality of the adolescent.

It is impossible in this summary to show the logical arrangement of the findings to each phase of the research. This has been done in the published report.[2] There are definite conclusions on the nature of student science interests and their significance. In nearly every instance, several phases of the research have contributed to the data on which each conclusion rests. On such points as the specificity of student interest, on sex differences, and on permanence of interest there is strong consistency in the findings. The findings of this research may be briefly summarized as follows:

Students in high school exhibit very distinct preferences in their science activities and interests. Their interests are not randomly distributed, nor do they seem related to the science courses studies in school. These students show strongest preferences for phases of science most closely connected with themselves and their problems. Hence strong interest is expressed in topics related to physiology, anatomy, health, and animal life. There are distinct differences between the preferences of boys and girls. Boys' preferences for certain specific aspects of physical science (electricity, airplanes, radio, etc.) are as strong as their interest in biological topics. This interest is lacking in girls whose biological interests are much stronger than boys'. Girls also express a stronger interest in astronomy. There are several other minor differences of interest present. These young people, especially boys, have a strong preference for scientific, manipulative activity. They are also interested in acquiring factual knowledge. "Applied" or "practical science," or ideas associated with the use of science, is of less interest to these adolescents.

If one defines "permanence" of interest in terms of educational potentialities, it is evident that these interests are permanent enough to warrant consideration in the science curricula. The data also suggest that the interests of high school students undergo slow, but definite, changes. Many of the strong preferences and sex differences of younger pupils diminish in the upper grades. In terms of voluntary activity in science, both in and out of school, the boys' participation is about five or six times

[2] Zim, Herbert S., *Science Interests and Activities of Adolescents*, Ethical Culture Schools, New York, 1940.

as great as that of girls. These voluntary activities lead the adolescent to use a wide range of sources of science information outside of the classroom. Scientific and pseudo-scientific magazines, books, home apparatus, science sets, and club activities are important sources of sciences used by adolescents.

Adolescents wonder about many things in which they do not express a more active interest. They wonder about life on other planets and conditions inside the earth, though they have little interest in other phases of geology or astronomy. Other topics, about which these students wonder, are closely related to their personal problems and are very similar to the interests expressed more actively.

Adolescents, interested in science, exhibit the same preferences as other adolescents. However, the ratio of time spent on voluntary science activities by the "interested" adolescent to the non-interested student is about eight to one. These interested students frequently exhibit a variety of psychological drives in their science work: emulation of a hero, compensation, and escape are examples. The case histories suggest that the interested adolescent has personal, family, and economic problems related to his intellectual interest in science. These must be considered in the guidance of pupils.

If one accepts the purposes of science in general education, it becomes clear how this knowledge of science interests may be used for both group and individual instruction. It indicates the strong concern of these young people with personal, social, and intellectual problems. There is much science information in the field of science applicable to the solution of these problems, which should find a place in the curriculum. The data also indicate that for the younger high school pupils there should be rich opportunity for experimentation and manipulative experience. Keeping sex differences of interest in mind, there may be emphasis on certain aspects of physical science, which are interesting to students because they are dynamic, dramatic, and realistic. The differences of interest of boys and girls imply that techniques for handling science with young adolescents should be such that advantages are taken of these differences. The present educational treatment is such that the differences become exaggerated and girls soon exclude themselves from several areas of science activity.

For the utilization of these preferences and differences in the high school science curriculum, no hard and fast rules can be

laid down. Consideration must be given to the total school situation and to the specific characteristics of the student body. There is much which science can offer that is significant to high school pupils. It should be the concern of science teachers to facilitate the contact between their pupils and this significant information, in such ways that the methods and purposes of science are also made clear.

For the individual who is interested in science, whose interests, ambitions, and vocational choice are in the field of science, there is a somewhat different problem. While we recognize that for the majority of high school pupils science should not have a vocational approach, we cannot neglect these young people, who for a period of years have expressed a continued interest in science, an interest which they envision as a vocational one. The data uniformly indicate that these students are in need of guidance. Occasionally, their interest is associated with types of activity, which hinder rather than help their total development. It is important that the interest in science play a normal part in the lives of these students rather than an exaggerated one. If their science interest is largely motivated by drives associated with tense personal problems, expert guidance may re-direct the students into other channels, or perhaps through the solution of the immediate personal problems a firmer foundation for intellectual and vocational science interests may be built.

With increased knowledge of the adolescent and of his interests, as expressed through science, data are available for the reorganization of science courses in secondary schools towards the end of making them more functional for the student and more adequate in the vital educational tasks which confront us.

FLASH PHOTOS TAKEN OF OCEAN BOTTOM

No place in the world, not even the bottom of the ocean, is safe from the prying eye of the candid camera and its accompanying flash bulb. A new kind of deep-sea photography, of use in fisheries management, was described before the meeting of the Limnological Society of America by Prof. George L. Clarke of Harvard University and the Woods Hole Oceanographic Institute. Prof. Clarke told of the biological application of apparatus invented by Dr. W. Maurice Ewing of Lehigh University for purposes of geographical research.

Dr. Ewing's deep-sea flash bulb camera can be lowered to a position near the bottom, where it gets a snapshot of an area about 2½ by 3½ feet in size. It has worked successfully in waters from about 125 feet to more than half a mile deep.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

1682, 5. *F. L. Miksa, Aurora, Ill.*

1685, 6, 9, 90, 1. *C. W. Trigg, Los Angeles City College.*

1692. *F. L. Miksa, Aurora, Ill.*

1689. *Deane Branstatter, Sullivan, Mo., A. B. Curtis, San Antonio, Tex.*

1690. *Richard M. Sey, Waterloo, N. Y., E. Ray Hancy, Scheldrake, N. Y., A. B. Curtis, San Antonio, Tex.*

1686. *Aaron Buchman, Buffalo, N. Y., Arthur Danzl, Collegeville, Minn., Clarence S. Warne, Romulus, N. Y., Walter R. Warne, Rochester, N. Y.*

1682. *Proposed by E. H. Cooper, South Bend, Ind.*

Find the sides of an inscribed quadrilateral, such that its area will be

$$\sqrt{(x+1)!},$$

x being the length of the longest side.

Solution by John P. Hoyt, Cornwall, N. Y.

If x, y, z, and w are the sides of an inscribed quadrilateral, the area is given by the formula:

$$A=\sqrt{(x+y+z)(x+y+w)(x+z+w)(y+z+w)}.$$

If we let x equal the longest side, it is necessary to find values of x, y, z, and w which will satisfy,

$$\sqrt{(x+y+z)(x+y+w)(x+z+w)(y+z+w)}=\sqrt{(x+1)!}$$

By actual trial, the smallest integral numbers which will do this are 3, 4, 5, and 7.

1693. *Proposed by John L. Wagner, Chicago, Ill.*

Find the value of

$$\frac{(4+\sqrt{15})^{3/2}+(4-\sqrt{15})^{3/2}}{(6+\sqrt{35})^{3/2}-(6-\sqrt{35})^{3/2}}=A.$$

Solution by Abraham I. Goodman, Brooklyn, N. Y.

$$A=\frac{(\sqrt{4+\sqrt{15}})^3+(\sqrt{4-\sqrt{15}})^3}{(\sqrt{6+\sqrt{35}})^3-(\sqrt{6-\sqrt{35}'})^3}.$$

By factoring,

$$A=\frac{7(\sqrt{4+\sqrt{15}}+\sqrt{4-\sqrt{15}})}{13(\sqrt{6+\sqrt{35}}-\sqrt{6-\sqrt{35}'})}.$$

Since

$$\sqrt{4+\sqrt{15}}=\sqrt{5/2}+\sqrt{3/2};\qquad \sqrt{4-\sqrt{15}}=\sqrt{5/2}-\sqrt{3/2}$$

and

$$\sqrt{6+\sqrt{35}}=\sqrt{7/2}+\sqrt{5/2};\qquad \sqrt{6-\sqrt{35}}=\sqrt{7/2}-\sqrt{5/2},$$

then

$$A=\frac{7(2\sqrt{5/2})}{13(2\sqrt{5/2})}=\frac{7}{13}.$$

Solutions were also offered by A. R. Haynes, Tacoma, Washington; George J. Ross, Brooklyn, N. Y.; Eugene Clark, Mason City, Ia.; A. B. Curtis, San Antonio, Tex.; John F. Wagner, Chicago, Ill.; William A. Richards, Berwyn, Ill.; Walter R. Warne Rochester, N. Y.; Brother Reginald, C.S.C. Holy Trinity High School, Chicago; C. E. Jenkins, Chicago; Paul C. Overstreet, Wilmore, Kentucky; Robert W. Woods-S. Lancaster, Mass.; H. Lazott, Worcester, Mass.; H. M. Zerbe, Wilkes, Barre, Pa.; C. W. Trigg, Los Angeles Calif.; David X. Gordon, Brooklyn, N. Y.; Samuel H. Barken, Brooklyn, N. Y.; B. Felix John, Pittsburgh, Pa.

1694. *Proposed by Hugo Brandt, Chicago, Ill.*

Find the smallest number x such that $x-a$ is divisible by $a+1$ without remainder; where a may be any of the numbers: 1, 2, 3, 4, 5, 6, 9, 11, 13, 14, 19, 20, 27, 29, 34, 41, 59, 69, 83, 104, 139, and 209.

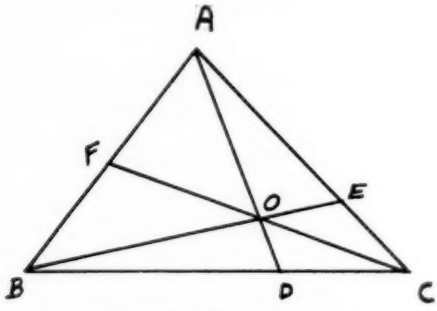
Solution by Proposer.

If $(x-a)$ is a multiple of $(a+1)$, as the problem implies, then $(x-a)+(a+1)$ also is a multiple of $(a+1)$. Now $(x-a)+(a+1)=x+1$, independent of any a. Hence if the different a's are called a_1, a_2, a_3, etc., $(x+1)$ must be a multiple of (a_1+1), (a_2+1), (a_3+1), etc. or the least common multiple of the following numbers: 2, 3, 4, 5, 6, 7, 10, 12, 14, 15, 20, 21, 28, 30, 35, 42, 60, 70, 84, 105, 140, and 210 which is 420. Hence $420=x+1$, and $x=419$.

Solutions were also offered by: H. Lazott, Worcester, Mass., David X. Gordon, Brooklyn, N. Y., Robert W. Woods, S. Lancaster, Mass., Deane Branstatter, Sullivan, Mo., Frances T. Miksa, Aurora, Ill., George J.

Ross, Brooklyn, N. Y., C. E. Jenkins, Chicago, Ill., Paul C. Overstreet, Willmore, Kentucky, A. T. Ashley, Vankleek Hill, Ont.

1695. *Proposed by John P. Hoyt, Cornwall, N. Y.*



In any triangle ABC, AD, BE, and CF are lines concurrent at 0, in the triangle and meeting the opposite sides at D, E, and F respectively. Prove that

$$\frac{AF}{FB}+\frac{AE}{EC}=\frac{AO}{OD}.$$

Solution by A. T. Ashley, Vankleek, Ont.

Making use of the theorem of Menelaus, in triangle ABD with CF as transversal,

$$\frac{AF}{FB}\cdot\frac{BC}{CD}\cdot\frac{DO}{OA}=1.$$

In triangle ACD with BE as transversal,

$$\frac{AE}{EC}\cdot\frac{CB}{BD}\cdot\frac{DO}{OA}=1.$$

Therefore

$$\frac{AF}{FB}=\frac{CD}{BC}\cdot\frac{OA}{DO}$$

and

$$\frac{AE}{EC}=\frac{BD}{CB}\cdot\frac{OA}{DO}.$$

By addition

$$\frac{AF}{FB}+\frac{AE}{EC}=\frac{OA}{DO}\left(\frac{CD}{BC}+\frac{BD}{BC}\right)=\frac{OA}{OD}\times 1=\frac{OA}{OD}.$$

Solutions were also offered by: Samuel H. Barkan, Brooklyn, N. Y., Frances E. Cook, Baïe Comeau, Quebec, Abraham I. Goodman, Brooklyn, N. Y., Aaron Buchan, Buffalo, N. Y.; David S. Gordon, Brooklyn, N. Y., C. F. Holmes, Washington, D. C., F. B. Miksa, Aurora, Ill., H. Lazott, Worcester, Mass., Paul D. Thomas, Norman Okla., Robert W. Woods, S. Lancaster, Mass., George J. Ross, Brooklyn, N. Y., and the proposer.

1696. *Proposed by John P. Hoyt, Cornwall, N. Y.*

If n and m are any two positive integers with $n>m$ show that

$$n^m-{}_mC_1(n-1)^m+{}_mC_2(n-2)^m\cdots(-1)^m{}_mC_m(n-m)^m=m!$$

A composite solution by A. T. Ashley, Vankleek Hill, Ontario, and David X. Gordon, Brooklyn, N. Y. is offered.

$$(1)\qquad (e^x-1)^n=\left(x+\frac{x^2}{2!}+\frac{x^3}{3!}+\cdots\right)^n$$

$$=x^n+\text{powers of } x \text{ with exponent greater than } n.$$

$$(2)\qquad (e^x-1)^n=e^{nx}-{}_nC_1e^{(n-1)x}+{}_nC_2{}^{(n-2)x}+\cdots(-1)^n{}_nC_me^{(n-m)x}+\cdots.$$

Selecting the coefficients of x^m from the expansion of e^{nx}, $e^{(n-1)x}$, $\cdots$ gives

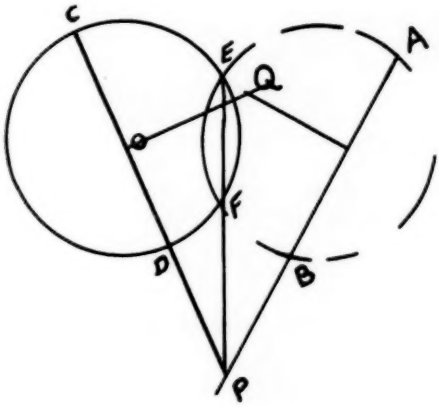
$$(3)\qquad \frac{n^m}{m!}-{}_nC_1\,\frac{(n-1)^m}{m!}+{}_nC_2\,\frac{(n-2)^m}{m!}-\cdots(-1)^m{}_nC_m\frac{(n-m)^m}{m!}.$$

If we equate coefficients in (1) $\equiv$ (2), for

(a) $n>m$, (3) $=0$
(b) $n=m$, (3) $=1$ and this proves the original proposition, since ${}_nC_r={}_mC_r$.

1697. *Proposed by W. R. Warne, Rochester, N. Y.*

To construct a circle through two given points and the extremities of a diameter of a given circle.



Solution by George J. Ross, Brooklyn, N. Y.

Let O be the center of the given circle and A and B, the given points.

If CD is the required diameter, then it meets AB at P which is the radical center of the given and required circles.

Since any three circles, taken two at a time, have their radical axes concurrent at the radical center, P is known and is found by constructing any circle through A and B cutting circle O in E and F. AB and EF intersect at P. Joining P to O determines CD, the required diameter. The center of the required circle lies at the intersection of the perpendicular bisectors of AB and CD. This center is Q.

Other solutions were offered by David X. Gordon, Brooklyn, N. Y.; Paul C. Overstreet, Wilmore, Kentucky; Robert W. Woods, S. Lancaster, Mass.; Howard D. Grossman, New York City, N. Y.; C. E. Jenkins, Chicago, Ill.; D. F. Wallace, and A. T. Ashley, Vankleek Hill, Ont.

1698. *Proposed by C. S. Warne, Romulus, N. Y.*

For any triangle prove

$$\frac{a}{\sin A}=\frac{a^2-b^2}{c\sin(A-B)} \quad \text{if} \quad A\neq B.$$

Solution by Brother Felix John, Pittsburgh, Pa.

From the Law of Sines,

$$\frac{a}{b}=\frac{\sin A}{\sin B}. \tag{1}$$

Hence

$$\frac{a^2}{b^2}=\frac{\sin^2 A}{\sin^2 B}, \tag{2}$$

and by division

$$\frac{a^2-b^2}{a^2}=\frac{\sin^2 A-\sin^2 B}{\sin^2 A} \tag{3}$$

$$\frac{a^2-b^2}{a^2}=\frac{(\sin A+\sin B)(\sin A-\sin B)}{\sin^2 A}. \tag{4}$$

Since $\sin A+\sin B=2\sin\frac{1}{2}(A+B)\cos\frac{1}{2}(A-B)$ and $\sin A-\sin B=2\cos\frac{1}{2}(A+B)\sin\frac{1}{2}(A-B)$, (4) becomes

$$\frac{a^2-b^2}{a^2}=\frac{\sin(A+B)\sin(A-B)}{\sin^2 A} \tag{5}$$

or

$$\frac{a^2-b^2}{\sin(A-B)}=\frac{a^2\sin(A+B)}{\sin^2 A} \tag{6}$$

$$\sin(A+B)=\sin C=\frac{c\sin A}{a}. \tag{7}$$

Substituting this value in 6 and simplifying,

$$\frac{a^2-b^2}{c\sin(A-B)}=\frac{a}{\sin A}.$$

Solutions were also offered by Miss Alice Neill, Sheldrake, N. Y.; Will Choatss, Auburn, N. Y.; Harry Warford Ogden, Buffalo, N. Y.; Andrew H. Beaver, Canoga, N. Y.; John Blackluck, Hastings, Minnesota; R. W. Woods, S. Lancaster, Mass.; Paul C. Overstreet, Wilmore, Ky.; A. R. Haynes; Dora Lane, Ovid Center, N. Y.; C. W. Trigg, Los Angeles, Calif.; David X. Gordon, Brooklyn, N. Y.; Desiah Browns Tecumseh, Lenowi, Mich.; Eva Rolison, Covert, N. Y.; Clarence S. Warnes, Sr.; Abraham I. Goodman, Brooklyn, N. Y.; Milton Brooks, Philadelphia, Pa.; Arthur Danzl, Collegeville, Minn.; Aaron Buchman, Buffalo, N. Y.; Rosella Peck, Britton, Mich.; C. E. Jenkins, Chicago, Ill.; Samuel H. Barkan, Brooklyn, N. Y. and the proposer.

STUDENT HONOR ROLL

The editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted to this department. Teachers are urged to report to the Editor such solutions.

1690. *Lee Rogsdon, Sturgeon, Mo.*

PROBLEMS FOR SOLUTION

1711. *Proposed by J. S. Bodine, Phoenix, Ariz.*

If the roots of $ax^2+2bx+c=0$ be real and different, those of $(a+c)(ax^2+2bx+c)=2(ab-b^2)(x^2+1)$ will be imaginary and conversely.

1712. *Proposed by John P. Hoyt, Cornwall on Hudson, New York.*

If D is a point outside an equilateral triangle ABC so located that $DB=DA+DC$, show that angle $ADC=120°$.

1713. *Proposed by John P. Hoyt.*

AB is any chord of a circle. C is its mid-point. DH and FE are any two chords drawn through C. D and F lie in the minor are subtended by AB. DE and FH are drawn intersecting AB at I and J respectively. Prove CI equals CJ.

1714. *Proposed by C. W. Trigg, Los Angeles, City College.*

A sphere of radius, r, is rolled along a horizontal floor by a plank of thickness, a, until it comes into contact with a vertical wall. If the bottom of the plank is now at a distance, b, from the foot of the wall find $r(a \leqq r, r < b \leqq 2r)$.

1715. *Proposed by Helen M. Scott, Baltimore, Md.*

A smooth cylinder, of 2-inch diameter, is in equilibrium, resting in a smooth hemispherical bowl, of 12-inch diameter. Half the bowl's volume of water is placed in it, which brings the water surface just in contact with the end of the cylinder. Find the length of the cylinder.

1716. *Proposed by Hugo Brandt, Chicago, Illinois.*

In a rectangular coordinate system, whose axes are OX east, OA south, OY upward, an irregular 3-sided pyramid with top T is given by its four faces. One of these is the base, $y=0$; another a vertical surface, $z=0$. The 2 remaining surfaces, $y=3x$, and $z=2(1-x)$, form the edge TS.

A wire is stretched from point $A(-4, 0, 0)$ across edge TS to point $B(6, 0, 0)$.

Determine the point of (assumedly frictionless) contact between edge E and wire.

NEW MILDEW-PROOF CLIMBING ROSE

Stephen Foster, writer of many of America's favorite songs, is commemorated in the naming of a new hybrid climbing rose, with fine red flowers, which was originated at the University of Arkansas by Prof. H. R. Rosen. The new variety is highly resistant to powdery mildew, fungus disease that ruins many climbing roses, and it can also withstand severe winter cold.

SCIENCE QUESTIONS

April, 1941

Conducted by Franklin T. Jones,
10109 Wilbur Avenue, S. E., Cleveland, Ohio

Contributions are desired from teachers, pupils, classes and general readers. Examination papers from any source whatsoever, questions on any part of the field of science, questions having to do with the pedagogy of science, tests,—in fact, anything that appeals to the reader or might appeal to other readers; also, anything that will help to make the subjects arrayed under SCIENCE more useful or more interesting to teachers and pupils.

Select your own topic. It will, most likely, be interesting to others.

Contributors to SCIENCE QUESTIONS are accepted, as they contribute, into the GQRA (Guild of Question Raisers and Answerers).

Classes and teachers are invited to join with others in this co-operative venture in science.

INTEREST RAISERS in ELEMENTARY SCIENCE

Please try these questions on a class—whether of the same age as the pupils who proposed them or of some other age.

If you like, send some of the original papers of the pupils answering, either from one pupil for the entire list or separate questions and answers from individuals.

Teachers are invited to get their classes to submit sets of questions for this series.

Mr. Wm. A. Porter, Wisconsin High School, Madison, Wis. (GQRA, No. 148) asked his Seventh Grade daughter—"What would you like to know about in science?" and she answered with *ten* questions given below. *An answer, and list of "Question Raisers in Elementary Science" by Patricia Jean Porter, Seventh Grade, Public Schools, Madison, Wis. (Elected to the GQRA, No. 366). (Questions are numbered consecutively with other "Interest Raisers")*

"I WOULD LIKE TO KNOW—

16. What is air made of?
17. If air has a pressure of 15 pounds per square inch, why aren't we crushed?
18. Why is the moon sometimes round and sometimes crescent-shaped?
19. Where do the insects stay during the winter?
20. Why do most birds fly south in the winter?
21. Why can't you run away from the moon in an automobile?
22. What keeps the earth and the other planets in their places?
23. Why does an object seen in a mirror always seem to be behind the mirror?
24. Why do you see your right hand as your left in a mirror?
25. Where does the water go when it evaporates?

Contributors to "Interest Raisers in Elementary Science" are to date—GQRA, Nos.

356. Elementary Science Class, Doan School, Cleveland, Miss Anna E. Burgess, Principal.
357. Dr. David W. Russell, National College of Education, Evanston, Ill.

358. Elementary Science Class, 6B, Almira School, Cleveland, Miss Dorothy C. Bliesch, Teacher.
359. Miss Mary Melrose, Supervisor of Elementary Science, Cleveland.
361. Miss Mary Byrne and pupils, Doan School, Cleveland
362. Elementary Science Class, 6 A, Almira School, Cleveland.
363. Elementary Science, Grades 4, 5 and 6, Doan School, Miss Irene VanChestein, Teacher.

April Contributors are given with their questions and answers in this issue.

Answers to Interest Raisers, 11 to 15, by Science Class of Mrs. Hellen Aufderheide, Science Teacher, School No. 54, Indianapolis, Indiana. (Elected to the GQRA, No. 367);

"Mr. Stinebaugh sent me your letter yesterday. I gave the test today and am rushing a few of the best answers on to you hoping they will reach you in time to be of some service."

(*The individual answers are very good.* ED.)

Complete set of answers by Bill Brendon, Science 8, Feb. 26, 1941, (Elected to the GQRA, No. 368).

Q. 11. *What causes an echo?*

Answer—An Echo is caused by sound rebounding from an obstacle.

Q. 12. *Why do we see lightning before we hear the thunder?*

A.—Because light travels faster than sound.

Q. 13.—*If a balloon is blown up in a warm room, and then taken out into the cold, would it get larger or smaller? Why?*

A.—It would get smaller because the cold air would make it contract.

Q. 14.—*Why can you see your breath on a cold day and not on a warm day?*

A.—On a cold day your breath can be seen because the moisture in your breath condenses in the cold air.

Q. 15.—*How can a fish stay under water so long and people cannot?*

A.—Fish breathe through their gills in water and then separate the oxygen from the water. A fish left on land would die because gills cannot separate oxygen from the air.

Questions 11 to 15 were proposed by the Fourth, Fifth, and Sixth Grade Science Classes of Doan School, Cleveland, Miss Irene VanChestein teacher (GQRA, No 363).

Lists of Questions have also been received from Miss Clara Headpohl, Science Teacher, Warner School, Cleveland, (Elected to the GQRA, No. 369) and from Boys' Science Class, Eighth Grade, School No. 54, Indianapolis, Ind. (Elected to the GQRA, No. 370).

DO YOU KNOW THE ANSWERS?

Beginning with this list—Nos. 131 to 135—a new departure will be made in the publication of ANSWERS. The answers will appear in the same number of SCHOOL SCIENCE & MATHEMATICS *in which the question appears. The Editor has concluded that the reader does not want to wait two months for an answer!!!*

The page on which the answers appear will not be stated but it will always be in SCIENCE QUESTIONS and on a page that follows the question.

Questions for inclusion in "Do You Know The Answers?" are invited; but please send the answer as well as the question whenever possible. FTJ.

131. A radio repair man drew the water for a bath, put on his ear phones, got into the tub, and then PLUGGED INTO THE ELECTRIC LIGHT SOCKET!!! Where did he go next? (*See answer, this number on a later page*) (This is an experiment YOU MUST NOT REPEAT.)
132. How many seeds in a pound? (*Use this question in any class in Agriculture, Biology, Botany, etc.*)
133. How long will weed seeds live in the ground and why?
134. Is it possible to destroy a small glass vial by very high frequency of sound? If so, why? (*Question and answer by Carter Frank (GQRA, No. 267), Riverside H.S., Buffalo, N.Y.*)
135. What is the difference between a photomicrograph and a microphotograph? (*Question and answer by Brother Felix John (GQRA, No. 17), Boys' H.S., Pittsburgh, Pa.*)

ANSWERS TO 121–125, from February, 1941, SCIENCE QUESTIONS.

121. The *sulpha drugs* are *sulpha-pyridine* and *sulpha-thiazole*.
122. Pneumonia is the deadly disease that is being conquered by these drugs.
123. "Freezing level" is a flight term and is the altitude at which the pilot is subject to attack by the ice menace. On an average winter's day in Britain it starts at 3,000 feet up; on an average summer's day at 10,000 feet. When you find hard frost outside your doorstep, ground level and freezing level are the same.
124. In the south and west fuelless hot water systems may be operated by using solar heat to warm the water.
125. Bats are supposed to guide themselves along tortuous cavern passages such as those in Carlsbad Caverns, New Mexico, by "flying the beam" of inaudible sound waves of very high pitch (supersonic echoes) which are reflected from the walls of the caverns. The bats themselves broadcast the sounds composing the beam—far too high-pitched for human ears—and then tune-in to them as they are bounced back from obstacles.

ANSWERS TO SOME QUESTIONS ABOUT MACHINE TOOLS

118. Hoke blocks are accurate to five-one-millionths of an inch of length.
119. The fact that Hoke blocks stick when wrung together may be explained by reason of molecular adhesion, or magnetism, or, most likely, because of surface tension due to a minute film of "wetness" from moisture or oil.
120. Airplane gears have to be accurately ground to prevent vibration which might shake the plane to pieces, also to lessen wear.

DENSITY AND SPECIFIC GRAVITY

AN ANSWER TO 896.

What is the pressure due to weight of sea-water at a depth of four miles, assuming a density of 1.025?

It was objected that density should have been given in grams per cubic centimeter or pounds per cubic foot.

Teachers were asked to submit this problem to their pupils without comment and ask them to "Get the answer" to see what interpretation the pupil placed upon the wording and what objection he raised, if any.

Solution supplied by the pupils of Dr. Wm. E. Harmish (GQRA, No. 354), University H. S., Urbana, Ill.

"My students in High School Physics solved the problem by assuming fresh water to weigh 62.4 pounds per cubic foot and first found the pressure per square foot and then the pressure per square inch by dividing by 144. This answer they multiplied by the "density" given. Some multiplied the 62.4 by "density" at the beginning. Their reason for using English units was that I teach them that, unless otherwise stated, water pressure is expressed in pounds per square inch."

(The Editor believes that well instructed pupils will use their heads and solve a problem such as this successfully even if the problem is stated, as in this case, with units omitted and "density" used instead of "specific gravity." The pupils in this case did what any practical man would have had to do—"Get the answer." They are to be complimented and do credit to their instruction.)

KEEPING UP WITH INDUSTRY

Teachers are invited to tell some of the ways in which they can keep up with industry and science.

919. How to keep up with science and industry? Chemistry of war and peace; alloys, metallurgy. Physics of direction-finding by radio and sound; optics; Biology of spraying and insect-protection; Conservation of land, out-door life, plants and trees, preservation of property values; And so on.
(Incidentally, how does the above tie into the "socialization of sicence teaching"?)

CORRECT or INCORRECT?

920. *Proposed by John M. Michener (GQRA, No. 117), Wichita High School East, Wichita, Kansas.*

Here are two problems for your SCIENCE QUESTIONS Department in SCHOOL SCIENCE & MATHEMATICS.

The following two sentences are taken from a standard textbook in chemistry, both on the same page:

When air is dissolved in water, more oxygen than nitrogen dissolves."

"Nitrogen dilutes the oxgen of the air and diminishes the intensity of its action."

Are these two statements correct? Give reasons for your answer.

NEAL WANTS TO KNOW

From Nathan A. Neal, (Elected to the GQRA, No. 365) Head of Science Department, James Ford Rhodes HS., Cleveland, Ohio. Please ask the readers of SCIENCE QUESTIONS the two questions given below:

921. "What are *five* of the most valuable facts (or by-products) that I, as a pupil, got out of my high school physics class this year?"
922. "What are *five* of the most valuable facts (or by-products) that I, as a teacher, believe my pupils got out of my physics class this year?"

Teachers and pupils are invited to send in their lists of five items. Some or all will be published in SCHOOL SCIENCE & MATHEMATICS, *and credit given by election to membership in the GQRA.*

HELP WANTED!

923. *Submitted by Virgil Henry's (GQRA, No. 271) Physics Class, Dexter, New Mexico.*

"I am enclosing a group of questions which were raised by my high school physics class. We have not been able to devise completely satisfactory answers for them and thought perhaps some readers of GQRA could help us out."

Submitted by Roma Ellen Stroud (Elected to the GQRA, No. 371).

923 (1)—In how many directions is it possible for a sphere, suspended in space to be rotated at the same time?

Submitted by Hansel Lee (Elected to the GQRA No. 372).

923 (2)—Why are the sun's rays still hot after traveling through ice?

Submitted by Carnelle Marshall (Elected to GQRA, No. 373).

923 (3)—Why does a speaker have to speak louder to a group of women than to the same number of men?

Submitted by Dorothy Carnal (Elected to the GQRA, No. 374).

923 (4)—If steam burns one worse than water at the same temperature, why does not this extra heat show on the thermometer?

Submitted by Clara Mae Bible (Elected to the GQRA, No. 375).

923 (5)—How can a steam boiler force steam out of one end and back into itself if the pressure is the same at both places?

Submitted by Beal Pinson (Elected to the GQRA, No. 376).

923 (6)—Do light and sound waves have acceleration?

Submitted by Billy Kerr (Elected to the GQRA, No. 377).

923 (7)—Why does a person blister worse on a cloudy day than a sunny day?

Submitted by Lawrence Lathrop (Elected to the GQRA, No. 378).

923 (8)—Why does a crowbar get hot when lying flat in the sun, but stays cool if stood upright?

Submitted by Helen Johnson (Elected to the GQRA, No. 379).

923 (9)—If 80 calories of heat are applied to one gram of ice to change it to one gram of water at the same temperature, why won't this heat affect the thermometer?

JOIN THE GQRA!

ANSWERS TO 131 to 135

These numbered questions appear on a previous page of SCIENCE QUESTIONS.

131. NEVER turn on a light or make an electrical connection while standing in water or on a wet floor. All water pipes are "grounded" and so is the electric circuit. You would be electrocuted as this radio man was. The next thing he did was to go to the undertaker.

132. Seeds in a pound each of Redtop grass-seed, 5,084,500; Kentucky Bluegrass, 2,201,300; Timothy, 1,230,100; Alsike Clover, 698,500; Orchard Grass, 586,500; Red Clover, 313,900; Sweet Clover, 259,400; Alfalfa, 219,500; Crimson Clover, 149,600; Rape Seed, 109,300; Hairy Vetch, 16,300; Wheat, 14,000; Oats, 12,700.

133. Government tests have shown that weed seeds may germinate upon being brought to the surface after being deeply buried for twenty years.

134. It is possible because sympathetic vibrations will cause the glass vial to vibrate so rapidly (if the frequency is high enough) that the mole-

cules will separate and the glass will break. (The frequency must be the natural frequency of the vial in order to produce resonance. ED.)

135. A photomicrograph is a micrograph (picture of a microscopic object) prepared by photography; a microphotograph is a very small-sized photograph (such as a book page on a motion-picture film).

GQRA—New Members, April, 1941

365. Nathan A. Neal, James Ford Rhodes HS., Cleveland, Ohio.
366. Patricia Jean Porter, Seventh Grade, Madison, Wis.
367. Science Class of Mrs. H. Aufderheide, teacher, School No. 54, Indianapolis, Ind.
368. Bill Brendon, Eighth Grade, School No. 54, Indianapolis, Ind.
369. Science Class———, Warner School, Cleveland, Miss Clara Headapohl, Teacher.
370. Boy's Science Class, 8th Grade, School No. 54, Indianapolis, Ind.

371. Roma Ellen, Stroud,
372. Hansel Lee,
373. Garnelle Marshall,
374. Hazel Carnal,
375. Clara Mae Bible,
376. Beal Pinson,
377. Billy Kerr,
378. Lawrence Lathrop,
379. Helen Johnson,

} All of Dexter High School, Dexter, New Mexico.

BOOKS AND PAMPHLETS RECEIVED

INTRODUCTORY COLLEGE MATHEMATICS, by William E. Milne, *Professor of Mathematics, Oregon State College*, and David R. Davis, *Associate Professor of Mathematics, State Teachers College, Montclair, New Jersey*. Revised Edition. Cloth. Pages xvi+440+82. 15×23.5 cm. 1941. Ginn and Company, Statler Office Building, Park Square, Boston, Mass. Price $3.00.

SHOP MATHEMATICS, by C. A. Felker, *Personnel Director, Marion Steam Shovel Company*. Cloth. Pages xii+380. 14.5×22.5 cm. 1941. The Bruce Publishing Company, Milwaukee, Wis. Price $2.20.

ESSENTIALS OF ALGEBRA, First Course, by Walter W. Hart, *Formerly Associate Professor of Mathematics, School of Education, University of Wisconsin*. Cloth. Pages vii+439. 13×20 cm. 1941. D. C. Heath and Company, 285 Columbus Avenue, Boston, Mass. Price $1.28.

ESSENTIALS OF HIGH SCHOOL ALGEBRA, *Formerly Associate Professor of Mathematics, School of Education, University of Wisconsin*. Cloth. Pages ix+582. 13×20 cm. 1941. D. C. Heath and Company, 285 Columbus Avenue, Boston, Mass. Price $1.60.

MATERIAL FACILTIES NEEDED IN THE TRAINING OF INTERMEDIATE GRADE TEACHERS IN SCIENCE, by Harry Allen Cunningham. Teachers College, Columbia University Contributions to Education, No. 812. Cloth. Pages vii+162. 15×23 cm. 1940. Bureau of Publications, Teachers College, Columbia University, New York, N. Y. Price $2.00.

GROWING TREE AND SMALL FRUITS, by H. B. Knapp, *Director, State Institute of Applied Agriculture, Farmingdale, L. I., N. Y.*, and E. C. Auchter, *Chief, Bureau of Plant Industry, United States Department of Agriculture.* Second Edition. Cloth. Pages xviii+615. 13.5×20.5 cm. 1941. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $2.75.

SCIENCE ON THE MARCH, by John A Clark, *Head of Department of Physical Science, Alexander Hamilton High School, Brooklyn, New York;* Frederick L. Fitzpatrick, *Professor of Natural Sciences, Teachers College, Columbia University, New York;* and Edith Lillian Smith, recently *Instructor, Boston Teachers College, Boston, Massachusetts.* Cloth. Pages xiii+572+x+iii. 14×21.5 cm. 1941. Houghton Mifflin Company, 2 Park Street, Boston, Mass. Price $1.72.

TEXT AND TESTS IN ELEMENTARY ALGEBRA, by David Eugene Smith, and William David Reeve, both of *Teachers College, Columbia University*, and Edward L. Morss. Paper. Pages ii+318. 19×26 cm. 1941. Ginn and Company, Statler Office Building, Park Square, Boston, Mass. Price 92 cents.

METEOROLOGY, by Donald S. Piston, *Physicist, The Twining Laboratories, Fresno, California.* Second Edition. Cloth. Pages x+233. 14×21.5 cm. 1941. The Blakiston Company, 1012 Walnut Street, Philadelphia, Pa. Price $3.00.

ELEMENTS OF GENETICS, by Edward C. Colin, *Chicago Teachers College.* Cloth. Pages xii+386. 14.5×21.5 cm. 1941. The Blakiston Company, 1012 Walnut Street, Philadelphia, Pa. Price $3.00.

ADVENTURES IN ALGEBRA, Second Course, by Murry J. Leventhal, *Chairman, Mathematics Department, James Madison High School, Brooklyn, New York*, and Charles Salkind, *Samuel J. Tilden High School, Brooklyn, New York.* Edited by F. Eugene Seymour, *Supervisor of Mathematics, State Education Department, Albany, New York.* Cloth. Pages xiv+493. 13.5×20 cm. 1941. Globe Book Company, 175 Fifth Avenue, New York, N. Y.

ELEMENTARY MATHEMATICAL CONCEPTS, by James H. Zant, *Associate Professor of Mathematics*, and Ainsley H. Diamond, *Head, Department of Mathematics, Oklahoma Agricultural and Mechanical College, Stillwater, Oklahoma.* Paper. 14.5×22.5 cm. 1941. Burgess Publishing Company, 426 South Sixth Street, Minneapolis, Minn. Price $1.50.

FIRE FROM THE AIR, by J. Enrique Zanetti, *Professor of Chemistry, Columbia University.* Paper. Pages ix+55. 10×16.5 cm. Columbia University Press, Morningside Heights, New York, N. Y. Price 50 cents.

HOUSING IN THE UNITED STATES, prepared by Archie W. Troelstrup, *New Trier Township High School, Winnetka, Illinois* for the Committee on Experimental Units of the North Central Association of Colleges and Secondary Schools. Paper. Pages x+80. 18.5×25 cm. 1941. Ginn and Company, Statler Office Building, Park Square, Boston, Mass. Price 48 cents.

CURRICULUM BULLETIN, No. I, University of Oregon: Social Guide for Teachers, by Hugh B. Wood, *Professor of Education, University of Oregon.* Paper. 44 pages. 21.5×28 cm. University of Oregon Co-operative Store, Eugene, Oregon. Price 40 cents.

CURRICULUM BULLETIN, No. 3, University of Oregon: Language Arts, A Study Guide for Teachers, by Hugh B. Wood, *Professor of Education, University of Oregon.* Paper. 33 pages, 21.5×28 cm. 1939. University of Oregon Co-operative Store, Eugene, Oregon. Price 35 cents.

CURRICULUM BULLETIN, No. 5, University of Oregon: Science, A Study Guide for Teachers, by Hugh B. Wood, *Professor of Education, University of Oregon.* Paper. 21 pages. 21.5×28 cm. 1939. University of Oregon Co-operative Store, Eugene, Oregon. Price 25 cents.

CURRICULUM BULLETIN, No. 7: A High School Science Program, University of Oregon High School, by Stanley E. Williamson, *Instructor in Education, University of Oregon* and *Instructor in Science, University High School.* Paper. 29 pages. 21.5×28 cm. 1939. University of Oregon Co-operative Store, Eugene, Oregon. Price 30 cents.

CURRICULUM BULLETIN, No. 11: Mathematics, A Study Guide for Teachers, by Vernon E. Kerley, *Instructor in Education, University of Oregon* and *Instructor in Mathematics, University High School.* Paper. 19 pages. 21.5×28 cm. 1940. University of Oregon Co-operative Store, Eugene, Oregon. Price 25 cents.

CURRICULUM BULLETIN, No. 12: Interdependence in Plant and Animal Life, A High School Science Unit, by Stanley E. Williamson, *Instructor in Education, University of Oregon* and *Instructor in Science, University High School.* Paper. 26 pages. 21.5×28 cm. 1940. University of Oregon Co-operative Store, Eugene, Oregon. Price 30 cents.

NEXT STEPS IN NATIONAL POLICY FOR YOUTH. Recommendations of the American Youth Commission of the American Council on Education. Paper. 18 pages. 15×23 cm. American Council on Education, 744 Jackson Place, Washington, D. C. Copies are available on request without charge.

BOOK REVIEWS

THE PHYSICAL SCIENCES, by Emmett James Cable, *Head of the Science Department;* Robert Ward Getchell, *Professor of Chemistry;* and William Henry Kadesch, *Professor of Physics, Iowa State Teachers College.* Cloth. Pages xvii+754. 14.5×23 cm. 1940. Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y. Price Trade: $5.00, School: $3.75.

This is one of the latest texts for survey classes in physical science. The aim of the authors is "to help the reader interpret intelligently the forces that make up the complex world in which he lives and to place at his disposal enough scientific knowledge to free his mind of prejudice and superstition. It should aid him to express himself accurately and to understand and appreciate scientific methods of arriving at the truth; also to form the habit of weighing values and reserving judgment until he knows all the facts."

It is essentially four small textbooks bound in one volume. Following a brief but very interesting introduction entitled "The Dawn of Science" is the first section of the book consisting of a discussion of the fundamental principles of physics—mechanics, heat, sound, light, and electricity and magnetism—about 300 pages. The most noticeable divergence from an abbreviated standard physics text is the expansion of the usual short chapter or few paragraphs on meteorology into three good chapters in this text.

A second section of 150 pages covers selected topics from the field of chemistry treating them in a quite orthodox manner. Here we find oxygen, elements and compounds, hydrogen, water, chemical symbols and equations, ionization and equilibrium, nitrogen, the halogens, the periodic classification of the elements, sulphur, the metals, carbon, and food chemistry.

The third section is on geology, with principal emphasis on structural geology and a few pages of historic geology, eighty pages in all. The final section of about a hundred pages is astronomy. A rather extensive list of references by chapters follows and a set of questions for each chapter completes the text.

The book is well written, reliable and attractive but, as indicated above, it does not present an integrated course in physical science.

G. W. W.

FOUNDATIONS OF MODERN PHYSICS, by Thomas B. Brown, *Professor of Physics, The George Washington University,* Cloth. Pages xii+333. 14.5 ×23 cm. 1940. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $3.25.

This text differs quite materially from others in this field by the emphasis placed on the practical applications of the discoveries in modern physics. Also an unusual amount of classical physics is included to give the necessary background for an understanding of the new investigations and theories. These features fit the text for classes of less mature students than those for which many of the other texts in modern physics were written. But this plan also results in some disadvantages. Descriptions and explanations of applications tend to detract attention from fundamental phenomena and, with the considerable space required for the older physics included, force the elimination of much of the new physics. However, it seems that the primary purpose of the author was to interest students in the more important recent developments rather than to give a critical survey of the entire field, and in this the text gives promise of success. Emphasis is placed upon the experimental development of the subject; descriptions and explanations are adequate to enable proper interpretation of the results of investigations; technical expressions and mathematical analysis are reduced to a minimum. Frequent references both to popular books and to more advanced texts enable both teacher and students to supplement the text.

G. W. W.

NEW TREND GEOMETRY, by Adele Leonhardy, *Department of Mathematics, Shorewood High School, Shorewood, Wisconsin;* Margaret Joseph, *Department of Mathematics, Shorewood High School, Shorewood, Wisconsin;* and Ralph D. McLeary, *Director of Mathematics, Brookline Public Schools, Brookline, Massachusetts.* Cloth. Pages xi+494. 12.5×19.5 cm. 1940. Charles E. Merrill Company, 381 Fourth Avenue, New York, New York.

The authors of this geometry text have added more of the desirable new features to the traditional material that is to be found in most of the newer textbooks. Among them are the following: (1) an explanation in the introductory chapter of the necessity for formal proof; (2) an analysis of the method of deductive reasoning with illustrations from non-geometric situations; (3) suggestions for the study of formal theorems and for the solution of originals; (4) gradual introduction of fundamental concepts based on situations familiar to the pupil; (5) a plan of proof preceding

each theorem; (6) an explanation of the algebraic ideas, principles, and processes needed in geometric situations; (7) a chapter on trigonometry; (8) an introduction to analytic geometry; (9) a survey of achievement at the end of each chapter; (10) organization into chapters instead of books.

There is a minimum course for the pupils with less than average ability and special work for the superior pupils. The figures are well-drawn and the full-page photographs are well selected.

The reviewer feels that this would be a very satisfactory text in that it would help to give the pupil a clear understanding of the fundamental concepts of geometry and a better understanding of the relationship of algebra, geometry, and trigonometry.

EDNA FELTGES
Wilson Junior College
Chicago, Illinois

AN INTRODUCTION TO COLLEGE GEOMETRY, by E. H. Taylor, *Head of the Department of Mathematics, Eastern Illinois State Teachers College, Charleston, Illinois*, and G. C. Bartoo, *Professor of Mathematics, Western State Teachers College, Kalamazoo, Michigan*. Paper. 127+29 pages. 16×23 cm. 1939.

According to the authors, this text not only provides an extension of Euclidean geometry but also offers an introduction to the ideas and methods of modern geometry needed for advanced study. Perhaps the best idea of the content is given by listing typical chapter headings: Directed Lines and Angles, Infinity, Properties of the Triangle, Harmonic Ranges and Pencils, Inversion, Cross Ratio, and Duality. The text contains approximately 500 exercises ranging from very simple ones to those which may present considerable difficulty to the student.

In the appendix are listed many theorems and corollaries from elementry geometry, also the proofs of some propositions frequently omitted from elementary texts. Illustrations of various methods of proofs maybe of considerable value to the prospective teacher.

CECIL B. READ
University of Wichita

FUNDAMENTALS OF PHOTOGRAPHY, by Paul E. Boucher, *Professor of Physics, The Colorado College*. Cloth. Pages xi+304+li. 15×23 cm. 1940. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N. Y. Price $3.00.

This book was written by the author as a textbook for a college course in photography. It is not an exhaustive treatise, but rather a presentation of the fundamental principles of the photographic process in such a manner that the student may be induced to avoid the "rule of the thumb" approach to the subject.

The style of the book is conventional. It begins with a history of photography and discussion of the choice of camera, continues to developers and fixing solutions, optics, properties of the photographic emulsion, the development process, printing processes, contact and projection printing. In addition there are chapters on camera shutters and shutter-speed measurements, the control of contrast, color characteristics of light filters and films, lantern and film slides and their preparation, after treatment of negatives, toning and dye staining of prints, and color photography. The laboratory experiments which follow the text are closely related to it and are especially valuable because the author has indicated the use of

readily available material. A formulary, a few tables, a glossary, and the index complete the book.

Although liberal use is made of H and D terminology the volume cannot be considered too technical. This relation between exposure and density in the form of the characteristic curve of the emulsion is first well developed, and then employed in explaining development and the control of negative contrast, tone reproduction and the printing processes, and intensification and reduction.

CLARENCE BEILMAN
Wilson Junior College

RECENT PROGRESS IN SOLID GEOMETRY

A new foundation for three-dimensional (solid) geometry was described in an address at the annual meeting of the American Mathematical Society by Dr. Leo Zippin of Queens College.

The essential idea of this new foundation for geometry is this:—instead of describing space by the usual points, lines and planes, one aims to describe it by the group of all the *motions* which are possible in space. This attack brings to bear the powerful modern mathematical notion of a *group*.

A systematic and logical treatment for ordinary geometry was first given by Euclid, over two thousand years ago. His set of axioms is still used, almost unaltered, by most high school geometry books today. Unfortunately there are some grave omissions in Euclid's treatment. These mistakes were corrected about 1900 by the famous German mathematician, David Hilbert. Hilbert also started to found geometry from the new point of view of studying the group of all possible motions. However, he worked out only plane geometry by this method.

The new results described by Montgomery and Zippin make it possible to extend Hilbert's analysis of plane geometry to give a similar description for solid geometry.

This extension depends on a classification of the rigid motions which are possible. There are two basic types, a translation and a rotation. A translation simply moves every point a certain distance in a given direction; a rotation revolves all of space about some fixed axis. The most general rigid motion possible is simply a rotation combined with a translation.

One first observes that one rigid motion followed by a second gives a combined motion which is again a rigid one. In other words, the combined result can still be described as a rotation plus a translation. Furthermore, after any rigid motion everything can be moved back to the starting point by a reverse motion. These two simple but essential facts are summarized by the mathematical statement that the rigid motions form a *group*.

This group requirement is the first axiom for the new foundations of geometry. There are only two more axioms necessary. The second one asserts that there are enough motions so that any one given point can be carried into a suitable collection of other different points. Finally, the third axiom connects the behavior of a given pair of points under a motion to the behavior of pairs of nearby points under the same motion.

From these axioms one can develop all of plane and solid geometry. Zippin's talk showed how the new techniques for analyzing the group of motions can be used explicitly to give new proofs for such well-known theorems as "the altitude of an isosceles triangle bisects the base," and "a straight line can intersect a sphere in at most two points."

The study of applications should indicate that mathematics is as essential in our scientific, industrial, and social progress as the mathematical method of thinking is in our intellectual development.
—RUTH MASON BALLARD

CONTENTS FOR MAY, 1941

Some "Middle-of-the-Road" Questions About Consumer Science Courses—*Kenneth H. Garren* 407

Should We Invert the Fractional Divisor?—*Walter A. Thurber* 412

Showing Filter Action with a Neon Lamp—*W. L. Fenner* 415

Note on Balancing Oxidation Equations by the Ion-Electron Method —*Jacob Cornog* 419

A Novel Plate Developing Tank—*W. A. Porter* 423

Student Wildlife Interests—*P. A. Davies* 425

The Combined Introductory Course in Secondary Science—*H. W. Baker* 428

A List of Fundamental Theorems in Geometry—*Joseph A. Nyberg* .. 432

Nature Study and Geography—*Edna Drill* 442

Science Fairs for Correlation of Subject Matter—*Ronald L. Whitney* . 447

The Principles of Physics—A Criticism—*H. M. Stockder* 449

The Present Biology Program and Its Relation to Adolescent Needs —*Veva McAtee* 452

The Law $\sqrt{a}\ \sqrt{b} = \sqrt{ab}$ Holds for All Numbers—*Luise Lange* 457

A Method of Directing and Utilizing Project Work—*Lee R. Yothers* .. 462

Psychology in Secondary Schools—*S. Edmund Stoddard* 468

Conducting a Community Star Party as a College Class Activity in Summer School—*David W. Russell* 472

Use the Electric Outlet for Demonstrating Vacuum Tubes—*Andrew Douglas* 478

Teaching of Mathematics at the Junior College Level—*Ruth Mason Ballard* 482

Name the Elements—A Game of Colors—*Milton G. Wolf* 486

Critical Phenomena—*Saverio Zuffanti* 489

Problem Department—*G. H. Jamison* 490

Science Questions—*Franklin T. Jones* 496

Books and Pamphlets Received 502

Book Reviews 504

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